A GLOBAL STRATEGY FOR HOUSING IN THE THIRD MILLENNIUM

Edited by
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and
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Preface

Sir Alan Muir Wood FEng, FRS, FICE

This book represents the proceedings of the second in a series of discussion meetings convened by The Royal Society with the aim of reviewing the ways in which human needs and national expectations can be served by technological developments in the 21st century.

How does this series of meetings relate to activities of The Royal Society, Britain's national academy of science, founded in 1660? As the third millennium approaches, The Royal Society decided that the time was opportune to attempt to look a long way ahead—longer ahead than the horizons customarily bounding technological prediction—towards discerning developments related to fairly basic human needs. While recognizing the interlinkages between human activities, for organizational practicality the resulting series of discussion meetings on issues for the future were on such themes as the environment, communications, transport, health and housing, the subject of this book. When immediate issues are addressed, problem areas and opportunities are found to concern predominantly engineering, architectural and social policy. With a longer horizon, however, sciences more remote from engineering are seen to have a strong potential role, often suggesting new cross-disciplinary activities of a nature increasingly fruitful in many fields of scientific advance.

For the most rapidly developing areas of technology, such as communications, the furthest horizon for profitable debate could scarcely exceed, say, ten years. For housing, contemplation of a low-energy, sustainable future demands a longer time-scale. The value from thousands of years of learning by trial-and-error is not to be discarded lightly. Some of the wisdom to be found distilled in these pages comes from those who attempt to find solutions for 'appropriate' housing which builds intelligently on the past, satisfying the complexities of people's needs against tomorrow's real and illusory choice of strategies, materials, techniques and opportunities for innovation.

In a world of increasing diversity and contrasts between richest and poorest, the challenge was accepted of addressing the extremes: the high-technology house and housing for those on sub-subsistence incomes; houses for temperate climates, and for the most hostile conditions. This book attempts the impossibility of achieving an overall coherence across its boundless subject area and, more confidently, of stimulating thought among all those with professional or personal interest in matters relating to housing.

Introduction

William Allen CBE, HonLLD, RIBA

Towards the end of the first millennium AD there were outspoken pessimists in Christianized Europe who believed that the year 1000 would be terminal for the world. Fortunately they were wrong, and with successful survival into the second millennium, confidence flowered into a period of great artistic, administrative and intellectual achievement.

Half way through that millennium geographical exploration opened the way for the development of world consciousness and alongside it the idea of acquiring knowledge by hypothesis and experiment took root. The Renaissance provided an intellectual climate so favourable for the growth of this initially tender plant—it had tried several times previously to develop but without success—that two thirds of the way through the millennium King Charles II founded this Royal Society to nurture it into fruitfulness. Today science and the scientific attitude have become the power tools of learning and by their aid many technologies have developed and flourished as norms of social activity.

So here we are, in the home of that Society, facing the last decade of this second millennium, advantaged by the possession of geographical detail of our globe, considerable knowledge of its present climates, some measure of the limits of its resources and a rapidly developing awareness that we inhabit a piece of planetary equipment that not only requires mangement but *must* be managed if it is to provide the circumstances in which existence is both possible and meaningful for humankind, and for whatever force it was that gave us meaning, and this planet on which to develop, in the first place.

So the second millennium AD is ending awesomely, and as we contemplate entry into the third, it makes the best of sense for a Society such as the Royal to address a challenge to each of several key areas of social mechanics to think hard about what lies ahead. Our responsibility is for shelter and other areas. Technology which has been or will be explored in this series includes the environment, health, transport, energy, communication and food.

We cannot say what will actually happen in the far distant future about housing, or any other technology, but we can identify parameters of the problems it presents and thus provide growth points for constructive thought about the data base that will be needed, for this must be gathered and structured continuously in a coherent and relevant manner for the purposes of good management on a global scale in the future.

That is the objective which the conference was designed to address but technology is not the totality of housing nor could we have addressed this totality within the compass of this meeting for it would take us into the equally large subject areas of architectural character, human well-being and the environment.

These concern the needs of the human spirit and if they are not satisfied, the evidence is that there is sometimes not much point in building the hardware in the first place. In this and other countries we have had this amply demonstrated in the second half of this century by the necessity to demolish, prematurely, housing which provided for the elementary technical needs of shelter but failed in these other respects, resulting in a waste of human endeavour and material resources. These may seem occasionally affordable when disguised by representation in money terms but behind this are unacceptable realities.

And so, having noted this important omission, what have we included and why?

First and fundamentally there is the matter of the global population size and family sub-division. The population on the planet clearly cannot continue to grow unchecked without becoming self-destructive, so what factors will from time to time determine sustainable limits? Is stability a desirable or attainable goal? Can we rely on warfare, disease, starvation or family planning as natural or voluntary controls? We look at population in our first paper and alongside it we have placed a paper on the related matters of politics, society and economics, essential for the development of man-kind's ability to manage the planet in the future.

We then look at climatic constraints on our occupation of the planet. The human sensory system determines by comfort criteria the nature of the indoor climate to which people aspire; the building envelope is our principal aid in achieving this in whatever external climate we decide to live, though today we supplement this by mechanical, electrical and electronic aids.

We will doubtless need to populate the more extreme climates as the struggle develops between population pressures and usable areas of the Earth and we examine the implications of maximizing the exploitation of the hot and cold climates as well as the temperate.

We next move closer to resources in discussions of materials for future housing and the industrialization of construction by total housing systems and to these we have added an examination of the rapidly developing technologies of communication and control, likely to be a substantial influence on the way we live.

Then, penultimately, we have two papers of a more general nature, appearing at first glance perhaps to be in conflict but actually likely to prove complementary, the first on technologies for development and the second on barriers to be surmounted in effecting change.

Finally, Professor Bender from California considers the strategies and options open to mankind as the next millennium confronts it with the kinds of problems presented in this volume.

I am sure we all look forward to the intellectual challenges now to be put before us.

1
Demography and urbanization
Michael Chisholm

1.1
INTRODUCTION

When we consider the role of technology in the provision of dwellings in the third millennium, we need to consider several inter-related questions: the quality and quantity of dwellings which will be required, where these dwellings are to be located and the resources that are available for housing provision. The scale of resources available is primarily a function of the wealth or poverty of the people, though governments may have a significant impact, mainly in richer countries, through the scale and nature of their direct provision, and through policies in respect of subsidies and taxation. In addition, differing tenure arrangements may have an impact on the way in which different societies dispose resources.

Table 1.1 provides a summary of these and other considerations, and provides a framework in which to think about the issues which are of most relevance. As a first approximation, I assume that international climatic contrasts will remain much as they are at present. It now seems highly likely that during the 21st century the globe's average temperature will rise by the order of 3–4°C, and that the rise will be lowest in low latitudes and highest in

Table 1.1 Factors affecting the changing international need for dwellings. Focus of interest is quantity and quality of dwellings and associated services. This tabulation is not exhaustive. Many of the variables interact

Factors to consider, nation by nation		
Population growth	Owner-occupier	Role of government:
Physical environment	Tenant	Direct provision
Urban-rural disposition	Extra-legal	Subsidies
Scale of urban settlements		Taxes
Income per person		etc.

high latitudes. Although these changes may have a dramatic impact on agriculture, sea defence problems and the like, the direct significance for house design and specifications will be comparatively small. The distinctions between hot, cold and temperate climates will remain. Consequently, in this paper we ignore the impact of climatic change, as being of limited relevance for the purpose in hand, even though of profound importance for human-kind in many other ways.

The starting point for thinking about housing needs in the next millennium is the number of people there will be, their geographical distribution and the resources (income) available with which to satisfy needs and desires. It would be foolhardy to attempt predictions of these basic variables, even at one-century intervals, over the span of the next millennium. It seems more useful to look perhaps three decades ahead, to the early part of the millennium, and to ask about the likely scale of problems to be encountered. It quickly becomes apparent that one can draw a number of general conclusions with a fair degree of confidence, subject to there being no unforeseen catastrophic event. We begin by considering the prospective number of inhabitants, in total and by broad geographical region.

1.2
POPULATION GROWTH

The most useful summary of population growth in recent years, with a forward look to the year 2000, is provided by the World Bank; Table 1.2 reproduces their data. This table shows that throughout the period from the mid-1960s, population growth rates in the low- and middle-income countries have exceeded the rate of growth in the high-income countries by a substantial amount. Indeed, growth rates of 2–3% per annum during the post-war period far exceed the growth rates experienced in these same countries before World War II, and also the growth that occurred in countries which are now classified as high-income (Grigg, 1982). Also evident is the general decline in growth rates since 1965–73, in the richer and in the poorer countries, with the expectation that during the last decade of the present century there will be a further decline.

In many of the more advanced nations, fertility has dropped to, or near, the replacement level. Unless there is substantial immigration, population growth in these countries is likely to fall below the 0.5% per annum expected in the period 1990–2000. It seems unlikely that there will be large-scale immigration into the richer countries, except possibly the United States; governments have become increasingly conscious of the problems, economic and social, of allowing sizeable inflows. It seems reasonable to suppose that in the early part of the next millennium annual population growth in the richer countries will be at or below 0.5%.

It does seem that growth rates in the poorer countries are set on a clear downward trend. Fertility is falling to match the reduction in mortality rates

Table 1.2 Population growth, 1965 to 1990, and projected to 2000 (from World Bank, 1990, p. 159)

Country group	*1989 population (millions)*[a]	*Average annual growth (%)* 1965–73	*1973–80*	*1980–90*	*1990–2000*
Low- and middle-income economies	4037	2.5	2.1	2.1	1.9
Low-income economies	2947	2.6	2.1	2.0	1.9
Middle-income economies	1090	2.4	2.3	2.1	1.9
Sub-Saharan Africa	479	2.6	2.8	3.2	3.1
East Asia	1566	2.7	1.7	1.5	1.4
South Asia	1132	2.4	2.4	2.3	1.9
Europe, Middle East, and North Africa	404	1.9	2.1	2.1	2.1
Latin America and the Caribbean	422	2.7	2.4	2.1	1.8
Severely indebted middle-income economies	506	2.5	2.3	2.1	1.8
High-income economies	789	1.0	0.8	0.7	0.5
OECD members	755	1.0	0.7	0.6	0.5
Total reporting economies	4826	2.2	1.9	1.8	1.7
Oil exporters	609	2.7	2.7	2.7	2.4

[a] The continental classification of the low- and middle-income economies does not sum exactly to the total shown.

occasioned by modern medicine, better hygiene and more reliable (if not better) nutrition. Two factors seem to be working in this direction. The enabling factor is the spread of family planning programmes in the poorer countries, since first adopted by India in 1952; at present, about 85 countries have some form of birth control programme, affecting 95% of the world's population. The second, and much more important, consideration is the growth of income that has been experienced and seems to be in prospect. This is a matter which anticipates the material in the next section but which is highly relevant to demographic trends. With a rise of living standards, an increasing proportion of the child population attends school, thereby shifting the economics of child-rearing towards smaller families. That shift is reinforced by improved health care, whereby a larger proportion of children survives into adulthood. Therefore, to provide for one’s old age in a society where pension schemes apply to a small minority, fewer children need to be born. In addition, the role of women in society is apt to change as development proceeds, in that they have more control over their lives than hitherto. In exercising that control, it seems to be fairly generally the case that women choose to have smaller families.

The evidence summarized in the next section suggests that most poor countries have broken out of the Malthusian trap (if they were ever in it), in which population is envisaged to expand to use the resources which are available, implying that incomes remain at the subsistence level. Incomes have in fact been rising and will probably continue to rise, thereby maintaining the social adaptations mentioned in the previous paragraph which lead to lower fertility and a consequential drop in population growth.

So we may expect population growth rates in the poorer countries to continue their downward trend. However, behaviour in the aggregate changes rather slowly, so it is reasonable to expect that there will be a large differential between the growth rates of the richer and the poorer countries for many decades to come. In the present context, though, it is not necessary to try to be precise about the magnitude of that differential, since it is abundantly clear from the 1989 distribution of population (Table 1.2) that by far the largest absolute number of additional people will be located in low-and middle-income countries for as far ahead as it is relevant to consider. This is true within the range of plausible possibilities for the rate of population growth in the poorer nations relative to the richer, as is illustrated in Table 1.3.

This table takes the 1989 population estimates as the datum. To obtain the figures for the year 2000, the expected growth rates for the period 1990–2000

Table 1.3 Some population scenarios to 2020

Country group	*Population (millions)*				
	1989	*2000*[a]		*2020*[b]	
			Low growth	*Middle growth*	*High growth*
Low- and middle-income economies	4037	4967	5488	6312	7242
Low-income economies	2947	3626	4006	4608	5287
Middle-income economies	1090	1341	1482	1704	1955
Sub-Saharan African	479	670	740	851	977
East Asia	1566	1825	2016	2319	2661
South Asia	1132	1393	1539	1770	2031
Europe, Middle East and North Africa	404	497	549	632	725
Latin America and Caribbean	422	514	568	653	749
Severely indebted middle-income economies	506	616	681	783	898
High-income economies	789	833	851	888	920
OECD members	755	798	815	848	882
Total reporting economies	4862	5800	6339	7200	8162

[a] Derived by applying the 1990–2000 growth rates shown in Table 1.2.
[b] See text for assumptions.

shown in Table 1.2 have been applied to the 11-year period from 1989. These figures for the year 2000 are subject to a margin of error but nevertheless may be regarded as reasonably probable, given that birth rates and death rates are unlikely to change dramatically. The figures for 2000 have been carried forward to 2020 on the basis of three differing assumptions, which, to an approximation, represent the lower and upper boundaries of possibility and the mid-point in between. The low growth scenario is based on the plausible assumption that growth in the high-income countries over the period 2000–2020 averages a mere 0.1% annually, and the implausible one that the poorer nations all experience an average of only 0.5%. In contrast, the high growth scenario assumes a continuation of the 1990–2000 growth rates (Table 1.2), of 1.9% for poorer nations (all experiencing the same growth rate) and of 0.5% in the high-income countries. The middle growth scenario, therefore, assumes an overall growth rate for the poorer countries of 1.2% and for the richer of 0.3%, half way between the upper and lower limits.

It is an easy matter to calculate from Table 1.3 the proportion of the population increment that would be living in the low- and middle-income countries under the three scenarios for 2020. Because already the bulk of the world's population lives in these countries (84% in 1989), the greater part of the total increase under any of the three scenarios will be in these countries: about 70% in the low-income countries and about 26% in the middle-income countries, leaving just 4% for the high-income nations.

Table 1.3 does not present forecasts of the future; it provides instead some approximation to the upper and lower bounds of possibility and a point midway between. The estimates serve to make it crystal clear that whatever actually happens within those bounds over the next three decades, about 96% of the world's extra inhabitants will live in the low- and middle-income countries, 70% in countries where the average Gross Domestic Product (GDP) per person in 1989 was only a little over $330 (World Bank, 1990, p. 160; GDP is a somewhat different measure than the Gross National Product (GNP) shown in Table 1.5). In other words, the required housing to shelter the world's incremental population will mostly be needed for people whose real income is extremely low.

In the next section, we examine evidence regarding the recent past and prospective future rates of growth of income per person. To conclude the present section and anticipate the next, we should note the effect that a decline in population growth rate, triggered by reduced fertility, has upon the dependency ratio. If we assume that the economically active population is aged 15–64, the dependency ratio measures the number of individuals below 15 and aged 65 or over as a percentage of the active population. The higher the percentage, the larger the number of people for whom each 'active' member of the society must provide. The connection is rough-and-ready, since many children under 15, and also persons over 64, contribute

Table 1.4 Child and old-age dependency ratios, 1975–1990 (from United Nations, 1989, pp. 220–223)

	Child[a]				*Old age*[b]			
	1975	*1980*	*1985*	*1990*	*1975*	*1980*	*1985*	*1990*
World	77.5	73.7	69.4	64.7	6.7	6.7	6.7	6.7
Developing countries	81.3	77.8	77.0	76.4	6.1	6.2	6.2	6.3
Africa	83.4	84.3	86.6	87.0	5.6	5.7	5.9	5.9
South and East Asia	76.1	71.3	66.9	62 .2	6.1	6.2	6.1	6.3
West Asia	84.5	82.9	82.0	84.1	5.5	5.3	5.4	5.2
Mediterranean	39.7	37.4	38.0	37.3	13.9	14.1	13.8	14.4
Western hemisphere	81.0	72.2	63.6	59.6	6.9	6.9	6.8	7.1
Developed market economies	38.1	34.3	31.6	28.9	19.0	19.2	18.8	19.6
United States	39.1	34.0	32.7	32.6	16.3	17.1	18.0	19.1
Europe	37.6	33.2	28.7	27.7	19.7	20.7	20.0	20.8
Centrally planned economies	36.3	37.6	37.7	35.5	15.6	17.2	15.8	16.6

[a] $\frac{\text{Population age 0–14}}{\text{Population age 15–64}} \times 100.$

[b] $\frac{\text{Population age 65+}}{\text{Population age 15–64}} \times 100.$

to productive activities, while in most of the wealthier nations full-time education continues after the age of 14. Table 1.4 records some recent estimates of dependency ratios. The child dependency ratio in the developing countries, although it has fallen somewhat in 25 years, remains more than twice the level of the developed market economies. Although the latter have old-age dependency ratios higher than is the case in the developing countries, the difference only partly offsets the gap in the child dependency ratios. Assuming that the demographic transition which has begun in the poorer countries continues, there will be a lag between the fall in child dependency ratio and rise in the old-age dependency ratio. This implies that the poorer countries enter the third millennium with a favourable trend in the proportion of dependents to active citizens, a fact that must have a generally beneficial effect upon the growth of output per person.

1.3
INCOME PER PERSON

Although an improvement in the dependency ratio is a factor favourable to growth in income per person in the poorer countries, the very high rate of population growth experienced in these countries has been, and continues to be, a major impediment. A pure Malthusian view—that population will always grow to the limit of available resources and thereby keep incomes at subsistence level—quite clearly does not fit the historical experience of the past one or two centuries. Nevertheless, there is much truth in the neo-Malthusian position that very rapid population growth can be a disadvantage. Nevertheless, despite the high rates of population growth which have been common in the Third World, income per person has in fact been rising, with the main recent exceptions being sub-Saharan Africa and Latin America (Table 1.5).

This table shows that the income gap is immense; the high-income countries had a GNP *per caput* 45 times as large as the poorest group shown, South Asia. The historical evidence indicates that the income gap between the poorest and richest countries has been widening since the late 1700s, and many are of the opinion that this trend will continue (Cole, 1981; Kahn, 1979). The existing income differentials are so great that there is no possibility they will be eliminated even over the next century. In the present context, however, the size of the income gap is not the issue of main importance. The crucial question is: can we expect real income *per caput* in the poorer nations to rise, fall or remain static? And can we guess at the probable rate of change over the foreseeable future?

For the present purpose, I assume that world population does in fact approach a stable total during the 21st century. I further assume that resource constraints, as postulated by Meadows (1972), will not prove to be the absolute limitation that some are inclined to suppose. With these two assumptions, it seems reasonable to expect a continuation in the growth of income *per caput* at a rate similar to that achieved in the postwar period. To the extent that the two assumptions prove to be wrong, it is likely that overall income growth will be lower than this historical experience suggests, and especially for the poorer nations if their population growth causes pressure on resources to grow more rapidly than coping strategies can be evolved. Therefore, in taking a fairly optimistic view of future growth prospects for incomes we are probably looking at the upper end of the range of possibilities.

Over most of the period since 1965, the low- and middle-income countries have enjoyed an income growth rate at about the level of the high-income countries, or above, with East Asia the outstanding success story: China, S.Korea, Taiwan, etc. East Asia accounts for about half the inhabitants of the low- and middle-income countries. South Asia, primarily the Indian subcontinent, has grown more slowly, yet even so GNP *per caput* has been rising; these countries account for a further quarter of the world's poor people.

It seems reasonable to suppose, therefore, that the majority of the poorer countries will experience a continuing rise in GNP *per caput,* which should help to maintain the downward trend in fertility and the beneficial effects of an improving dependency ratio. However, improvement in the absolute

Table 1.5 Population and GNP per caput, 1980, and growth rates, 1965–89 (from World Bank, 1990, p.160)

	1980 GNP (billions of dollars)	*1980 population (millions)*	*1980 GNP per caput (dollars)*	*Average annual growth of GNP per caput (%)*					
1965–73	*1973–80*	*1980–86*	*1987*	*1988*	*1989*[a]				
Country group									
Low- and middle-income economies	2406	3359	700	4.0	2.6	1.5	2.7	3.4	1.2
Low-income economies	784	2459	320	3.6	2.4	4.0	3.9	6.8	1.8
Middle-income economies	1622	900	1760	4.6	2.4	0.1	1.8	1.1	0.8
Sub-Saharan Africa	213	362	570	3.0	0.1	–2.8	–4.4	–0.8	0.5
East Asia	586	1363	420	5.4	4.4	6.6	0.9	6.1	2.3
Europe, Middle East and North Africa	590	335	1740	5.6	2.1	0.8	–0.6	0.1	0.6
Latin America and the Caribbean	716	348	2000	4.1	2.4	–1.6	1.5	–0.8	–0.8
Severely indebted middle-income economies	791	419	1840	4.2	2.6	–1.5	1.2	–0.4	–0.7
High-income economies	7923	742	10740	3.5	2.2	1.7	2.5	3.5	3.1
OECD members	7663	716	10750	3.5	2.2	1.9	2.8	3.7	3.1
Total reporting economies	10329	4101	2520	2.7	1.5	0.9	1.8	2.7	1.7
Oil exporters	964	479	1980	4.6	2.8	1.6	–2.5	0.5	—

[a] Preliminary

Table 1.6

Annual compound growth (%)	1.5	2.0	2.5	3.0	3.5	4.0
Years required to double income	47	35	28	23	20	18

level of resources available for each person in the poorer nations will be slow. If we assume a steady compound rate of growth in income *per caput,* then the number of years required for income to double is as given in Table 1.6.

Tables 1.2, 1.3 and 1.5 together demonstrate several facts which are indisputable. First, the great majority of the world's population currently lives in the low- and middle-income countries, about one-fifth in the low-income countries which in 1980 had an average GNP *per caput* of only $320. Second, well over half of the growth in population will occur in these self-same low-income countries (Table 1.3). Third, although we may expect output to grow more rapidly than population, it will be several decades before incomes double. Manifestly, therefore, the great majority of the world's population, for a long time into the next millennium, will have very low incomes. To meet their needs for shelter, low-cost solutions will be essential.

A rural population can usually provide itself with rudimentary but serviceable shelter at minimal cost, using local materials which can be gathered for nothing but the expenditure of labour: bamboo, mud, thatch, etc. In practice, therefore, much existing accommodation has been provided for little or no cash outlay, but is of course lacking facilities which in richer countries are taken for granted: running water, sanitation, electric light and adequate cooking facilities. Were it the case that the prospective increase in world population would occur in rural areas, then at least it would be possible to maintain existing standards of accommodation, inadequate though these may be. If much of the increase is likely to be urban, then the problem of providing enough dwellings, even at minimal standards, may be much greater.

1.4 URBANIZATION

Two matters are of particular interest to us, namely, recent trends in urbanization and prospects for the future, and the consequences which stem from these trends. In approaching these questions, we need to be conscious of the acute problems there are over comparability of data, given the differing definitions of what constitutes a town or city. As a result, the data which will be presented must be treated with even greater circumspection than the material which has already been discussed.

1.4.1 Trends

The most recent and thorough statistical study of urbanization was published by the United Nations in 1987. This contains a wealth of data, at the global, regional, national and city scales of consideration; readers who want amplification of the points to be made in the present paper should refer to this source.

Table 1.7 summarizes data on the urban population in 1970 and 1980, with projections to 2025. If we compare the projections for 1990 with 2025, total population was expected to increase by 2960 million, of which practically all will be accounted for by urban growth (2698 million). Furthermore, it is the urbanization of the poorer countries which gives rise to this expectation; in absolute terms, the richer countries contribute a very small share of the expected urban increase. Note also that quite early in the 21st century the rural population of the poorer countries is expected to peak at just over 3000 million and is then expected to decline.

Even if the United Nations' estimates prove to be substantially in error, two points can be made with reasonable confidence. First, the world seems to be in transition towards the time when virtually all the net addition of people will be housed in towns and cities. And second, it is already the case that the greater part of population increase is urban, so that the need for extra dwellings is already predominantly urban rather than rural. Inevitably, there are substantial regional and national variations but, at the global scale, these conclusions are robust.

Table 1.7 The growth of the urban and rural populations, 1970–2025 (from United Nations, 1987, Tables 2 and 3)

Total population (millions)	*1970*	*1980*	*1990*	*2000*	*2010*	*2020*	*2025*
World							
Total	3693	4450	5246	6122	6989	7822	8206
Urban	1371	1764	2234	2854	3623	4488	4932
Rural	2322	2685	3012	3268	3366	3334	3274
More developed regions							
Total	1047	1137	1210	1277	1331	1377	1396
Urban	698	798	877	950	1011	1063	1087
Rural	350	338	333	327	320	313	310
Less developed regions							
Total	2646	3313	4036	4845	5658	6446	6809
Urban	673	966	1357	1904	2612	3425	3845
Rural	1973	2347	2679	2941	3046	3021	2964
Percentage urban							
World	37	40	43	47	52	57	60
More developed regions	67	70	73	74	76	77	78
Less developed regions	25	29	34	39	46	53	57

The nature of the urbanization process is also changing. For a long time, large-scale urbanization was associated with the industrialization of the presently richer countries, with cities such as London and New York the largest in existence. Since World War II, however, important changes have become evident. In several of the richer countries, the bigger cities have ceased to grow, are growing only slowly, or are actually losing population. In Britain, parts of the United States and in some part of Europe, the past two or three decades have seen a shift away from the problems of containing urban growth.

In sharp contrast, several cities in low- and middle-income countries have continued to grow rapidly. Mexico City is now thought to be the world's largest city, with approximately 20 million inhabitants, and is expected to reach 25 million by the end of the present decade (Table 1.8). By that time,

Table 1.8 Urban agglomerations with more than 10 million inhabitants 1970, 1985 and 2000. 1970 cities rank ordered by population. For 1985 and 2000, the *additional* cities are rank ordered (from United Nations, 1987, Table 6)

	Population (millions)		
	1970	*1985*	*2000*
New York	16.3	15.6	15.8
Tokyo/Yokohama	14.9	18.8	20.2
Shanghai	11.4	12.0	14.3
London	10.6	10.4	10.5
Mexico City		17.3	25.8
Sao Paulo		15.9	24.0
Calcutta		11.0	16.5
Buenos Aires		10.9	13.2
Rio de Janeiro		10.4	13.3
Seoul		10.3	13.7
Greater Bombay		10.1	16.0
Los Angeles		10.1	11.0
Tehran			13.6
Jakarta			13.3
Delhi			12.0
Karachi			13.2
Beijing			11.2
Dacca			11.2
Cairo			11.1
Manila/Quezon			11.1
Bangkok			10.7
Osaka/Kobe			10.5
Moscow			10.4

Table 1.9 Population of the 99 largest cities

Year	*Population (millions)*	*As a percentage of the world's urban population*
1970	346	25.2
1985	488	24.6
2000	659	23.1

São Paulo will have about 24 million, and both Calcutta and Bombay will be larger than any city in the richer countries other than Tokyo/Yokohama, this city having fallen from first rank in 1985 to third in 2000. Table 1.8 illustrates two points of considerable interest. Big cities are no longer the special preserve of the richer countries, but are a widespread feature in rich and poor countries alike. Second, the biggest cities now dwarf the biggest European cities and all but New York in the United States. These newly emergent mega-cities, as they are often called, are inhabited by people whose incomes are exceedingly low; indeed, many live in extreme poverty. Cities of 20–30 million inhabitants are a new phenomenon, posing severe and novel problems of governance and for the provision of basic facilities.

Important though mega-cities are, their existence should not blind us to the continuing importance of smaller cities. The table from which Table 1.8 has been compiled lists the 99 cities in the world which in 1985 individually had a population of 2 million or more. The total population in these cities can be compared with estimates of the world's urban population in the same years, see Table 1.9. Cities that were below the 2 million threshold in 1985 will continue to accommodate three-quarters of the world's urban population well into the next century, possibly increasing their share slightly.

According to Preston (1988, p. 14), the greater part of urban growth in the developing countries arises from the natural increase of the existing urban population. This finding, which is contrary to the widespread belief that it is migration from rural areas that drives urban expansion, is based on 29 countries for which data exist allowing a disaggregation of total growth into its components. Of these 29 countries, 24 experienced a rate of natural increase in urban areas that exceeded the rate of inward migration, a fact which can be attributed in part to lower infant mortality rates in the cities than in rural areas (Gilbert and Gugler, 1982, p. 53; Linn, 1983, pp. 18, 19). Although this may be the common situation, there seems to be little doubt that some of the most rapidly growing cities, such as Mexico City, have depended on large-scale migration to maintain the tempo of expansion.

1.5
AN OVER VIEW OF HOUSING NEEDS

The broad outline of the future need for dwellings is already clear from the material which has been discussed in the preceding sections. For the purpose of this volume, it may be useful to amplify this outline by examining some of the consequences for technological developments in housing. Given the constraints of space and time, it is convenient to distinguish between the high-income countries as a group, and the low- and middle-income countries as another. This will allow broad contrasts to be drawn out, though the richness of country-by-country detail is lost.

1.5.1
High-income countries

In 1961, Jean Gottman published his pathbreaking study of the megalopolis of the northeastern seaboard of the United States, and just 12 years later Peter Hall published his two-volume study of the containment of urban England. These studies mark the climax to a long period in which the cities of Europe and North America were simultaneously becoming larger and larger, and were becoming more firmly connected with other urban centres in a complex web of interactions. Since then, the evidence has become abundantly clear that the bigger cities in Britain, the United States and elsewhere have ceased to grow, or have seen their growth checked, and have in many cases begun to lose population; this is often linked to the move of employment to the suburbs and beyond, to smaller cities and even to rural areas. Credit is usually given to Berry (1976) for first recognizing this reversal and, more particularly, for coining a phrase to describe the new trend: counterurbanization. Since then, there has been considerable interest in, and anxiety about, the population and employment losses of many of the bigger cities (see, for example, Champion 1989; Cheshire 1989; Ewers *et al.* 1986; Lawton 1989).

The changing location of where people wish to live implies a double problem: that of adapting and upgrading the existing stock of older dwellings, or their replacement, usually in the more central parts of cities; and providing new dwellings outside the larger cities. In both cases, the main problem lies in providing housing for people on incomes that are low by the standards of the richer countries; the plea for low-cost housing is widespread, certainly in Britain. Outright homelessness affects only a small number of people, though the number in London has risen sharply in recent years.

Since population growth in most of the richer countries is comparatively modest, the main components of demand for new housing are: the shifting location of desired residence; replacement of obsolete dwellings; household formation; and second home ownership. In addition, there is the continuing need to maintain and to upgrade the existing stock. Once the absolute shortage of housing that characterized the western countries at the end of World War II had been rectified by about 1970, attention has been shifting steadily to the improvement of existing dwellings and the imposition of higher standards for new construction. The rate at which quality improvements will proceed depends on the complex interplay of the role which governments perceive for themselves, the extent to which public and private funds can be mobilized, tenure arrangements and, finally, technological changes in housing provision and the provision of related services, including transport. Most of the discussion focuses on the first three items, and especially the role of central government and the significance of tenure (Vliet and Weesup, 1990).

Three pressures exist for innovation in the design and construction of dwellings, over and above the competitive pressure to keep initial costs as low as possible: to minimize maintenance costs; to use environmentally friendly materials; and to minimize the consumption of energy for running the dwelling. High wage costs make recurrent maintenance (e.g. exterior painting) an increasingly expensive matter; high specifications and the use of durable materials can reduce the long-term maintenance bill, whereby an increase in initial costs can be fully justified. Environmental concerns imply a continuing search for new building materials, to use what is currently waste material, to re-use materials generated by the demolition of buildings, or to substitute materials that are plentiful for those which cause environmental damage to produce. And anxieties about the greenhouse effects of energy production, plus the prospect that energy will become increasingly expensive, provide an incentive for governments and for individuals to economize in the use of domestic energy. However, the encouragement of responses to these pressures depends crucially on the success, or otherwise, of governments in arranging for the appropriate market signals to operate, and in setting the technical specifications for new buildings and for upgrading existing ones.

1.5.2
Low- and middle-income countries

The greater part of the world's need for additional dwellings will be in the poorer countries for the foreseeable future, and most of the need will have to be met in rapidly expanding urban settlements. Furthermore, it is clear that in absolute terms incomes will remain extremely low, even if quite rapid growth is achieved. Consequently, most of the housing provision will have to be at very basic, minimal standards, usually with two or three persons, even more, for each 'room'. The starting point for thinking about housing provision cannot, therefore, usefully be based on some notion of an 'adequate' standard, since that implies a cost which cannot conceivably be met in the foreseeable future. An alternative approach is to take the poverty line, which itself contains a considerable element of subjectivity, and in any case varies from one country to another, and then to estimate the resources that would be needed to bring housing standards up to this poverty line for all those who are below this level. Linn (1983, pp. 138–42) reports a World Bank study carried out in 1980 which made such estimates for 35 developing countries, on the assumption that the programme extended over the 20-year period from 1980 to 2000. The results of this study are summarized in Table 1.10. Linn comments that 'These investments are probably not within the range of fiscal feasibility' and concludes from this f fact that 'A feasible housing strategy for these countries would therefore have to employ standards even lower than those implied by housing expenditure at the poverty threshold' (Linn, 1983, p. 141).

The alternative conclusion would be to recognize the role of squatter, self-help housing. Throughout the poorer nations of the world, large-scale illegal (sometimes legal) settlement is occurring, frequently as organized 'mass

Table 1.10 The financial implications of a 'basic needs' housing strategy in selected developing countires, 1980–2000 (from Linn, 1983, pp. 140,141)

Region and country	*Annual investment*	
	As a percentage of government revenue	*As a percentage of GNP*
Middle-income Asia		
Group average	4.3	0.5
Highest: Philippines	11.0	1.2
Lowest: Korea	1.0	0.1
Sub-Saharan Africa		
Group average	5.4	1.0
Highest: Tanzania	14.0	3.0
Lowest: Zambia	0.2	0.1
Europe, Middle East and North Africa		
Group average	5.5	1.1
Highest: Tunisia	8.1	1.8
Lowest: Egypt	3.5	0.6
Latin America		
Group average	7.8	0.9
Highest: Mexico	29.0	2.3
Lowest: Chile	1.1	0.1
Low-income Asia		
Group average	24.4	3.0
Highest: Bangladesh	70.5	5.6
Lowest: Sri Lanka	7.0	1.8

invasions'. A common pattern, therefore, is for occupation to be followed by initial building by the squatter family, with the provision of rudimentary services coming some time later, and only afterwards some semblance of planning to try to bring order to established communities. At some point in this process, legal title may be granted, but often only after overt conflict between squatters and the state or private landowners on whose land the settlement has taken place. The grant of title, or reasonable security of tenure, is a necessary condition for the investment that is needed to provide minimal services and for the upgrading of dwellings. Usually the initial construction is of flimsy materials, which may be scavenged from refuse tips; subsequently, as families become economically established and gain title, more permanent structures are erected, room by room, using the labour of the family itself so far as is possible (Baróss and Linden, 1990; Gilbert and Gugler, 1982; Gilbert *et al.,* 1982; Gilbert and Ward, 1985; Gugler, 1988). Squatter settlements are not necessarily to be equated with slums, especially as improvements are made through the self-help process, though it is undoubtedly the case that standards are very low by the norms of western society.

The scale of the informal housing sector in the poorer countries is indicated by the data given by Gilbert (1990, p. 20) and Linn (1983, pp. 12, 13). Linn's data refer to 66 cities, located throughout the developing world, for various dates in the late 1960s and early 1970s. Lumping together slums and squatter settlements, their population is shown as a percentage of the city total. The median value was 40%, with a range from 1.5% in Beirut (in 1970) to 90% in Yaounde and Addis Ababa. Gilbert's data are for just five cities in Latin America; they show a rapid growth in the relative importance of squatter settlements, reaching 61% of the population of Caracas in 1985.

From a western perspective, the poverty and squalor found in the squatter or informal settlements which comprise such a large proportion of city populations in developing countries are deeply disturbing. Yet we should not overlook the fact that circumstances are generally even worse in the rural areas. This is evident indirectly through the evidence of infant mortality rates, which are higher in rural areas than in urban settlements. Confirmation is found in the data collated by Linn for the number of people who share a room, and by access to electricity, water supply and facilities for the disposal of excreta. In general, urban areas score well by comparison with rural areas. This is despite the fact that squatter settlements generally occupy the least salubrious land (Gilbert and Ward, 1985, pp. 61–129).

For the foreseeable future, it is quite clear that the scale of housing need in the poorer countries will ensure the continuing importance, and probable dominance, of the informal, squatter mode of provision. Public housing projects, although they aim to be low cost, set standards which are too high for most to be able to afford. The challenge, therefore, is a double one. To find legal and administrative means to facilitate rather than hinder self-help. And to find very low cost ways to assist the self-help sector in providing itself with the basic elements of housing and associated services. This may not be a glamorous task, but it is undoubtedly one that could help a large proportion of humanity to improve its own lot. While there has been a considerable literature on the first of these problems (see the literature already cited and in addition Payne (1989) and Ward (1982)), I am not aware of published work on the latter, the technological challenge. That may reflect my ignorance, but I fear this is not in fact the case. For example, the recent two-volume study, *The metropolis era,* edited by M.Dogan and J.D.Kasarda, pays only fleeting attention to technological matters and ignores the potential role of technology in the provision of housing. Even the solution offered by the Intermediate Technology Development Group at the 1991 Earls Court Ideal Home Exhibition will probably be too expensive for many, if not most, of the world's population in the early part of the third millennium; ITDG displayed a house which could be built with materials costing about £100 in an African country such as Kenya (*Small World,* 11, 1991, p. 2).

1.6
CONCLUSION

Broadly speaking, we can divide the world into two groups of countries, the richer and the poorer, with very different housing needs. In the richer countries, the need is no longer for massive construction programmes, although new building is still needed. The real need in these countries is to continue to raise the standard of the existing stock and to set higher standards for new construction. At the same time, there will be a continuing need to help those at the lower end of the income scale to get access to accommodation deemed acceptable by society. The main technological challenges arise from the pressure to reduce costs and yet raise quality, and from environmental concerns. In contrast, the overwhelming need in the poorer countries is, first, to provide additional dwellings to house the population increment and, second, to upgrade existing accommodation to the pitifully low standards set by one's judgement of the poverty threshold. The need for massive amounts of quite basic accommodation sets a different agenda for the technological needs as compared with the richer countries. This agenda may prove a much more difficult one than that faced by the richer countries, yet it is one that affects a far larger number of people.

APPENDIX 1.A
World Bank definitions

The *World Bank Development Report 1990* gives the following definitions relevant for the country groupings used in this essay.

High-income economies	GNP *per caput* of $6000 or more in 1988.
Middle-income economies	GNP *per caput* of over $545 but under $6000 in 1988.
Low-income economies	GNP *per caput* of $545 or less in 1988.
Sub-Saharan Africa	All countries south of the Sahara except South Africa.

Europe, Middle East and North Africa	Eight countries in Europe (Cyprus, Greece, Hungary, Malta, Poland, Portugal, Romania and Yugoslavia), plus all the countries of North Africa and the Middle East, and Afghanistan.
East Asia	All the low- and middle-income countries east of and including China and Thailand.
South Asia	Bangladesh, Bhutan, India, Myanmar, Nepal, Pakistan and Sri Lanka.
Latin America and Caribbean	All American and Caribbean countries south of the United States.

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2
Housing after 2000 AD: the likely effects of political, social and economic change

R.Best

2.1
THE WORLD SCENE

Homelessness in Bangladesh, Africa and the Middle East has been in the headlines in 1991. Natural disasters and wars—sometimes with one compounding the other—have afflicted hundreds of thousands of people this year. But most of the world's housing problems are of a less dramatic nature. Millions upon millions live in shanty towns and city slums.

Such conditions compound problems of ill health, old age, racial prejudice, mental illness and so many other social evils. Without a decent home it is difficult for family life to be fostered, for education to be successful and for talent to be developed.

The hope must be that as humankind moves into the third millennium, not only will the world become richer but its riches will reach every part of the globe. Maybe in the decades ahead the 'peace dividend' will mean that the resources devoted to warfare can be redirected to fighting other ills. If 500000 skilled personnel from many countries, together with their sophisticated equipment, can be swiftly airlifted to wage war in the Middle East, perhaps similar resources will be applied in the years ahead to over-come the emergencies of sudden homelessness and famine. And, through the self-help of the developing countries, backed by the finance and technology of the most developed countries, wealth will be generated which can provide lasting solutions to housing problems.

Are there lessons for the emerging economies from long-established ones like Britain's? As greater prosperity reaches the Southern nations, are there signposts from those in the North which have already trod a similar path? Indeed, are there lessons learnt in Britain which could indicate mistakes to be avoided by other developed countries?

I consider the likely effects of political, social and economic changes in Britain, in the hope that this builds a helpful case study for others.

2.2
BRITAIN AS A CASE STUDY

Britain remains one of the world's most prosperous countries and the great majority of its population enjoys housing conditions beyond the imagining of most nations. In 1986, 90% of Britain's housing contained all the basic amenities and was in a decent state of repair (Department of the Environment and Welsh Office, 1986); three quarters of Britain's homes now have central heating, compared with one quarter 20 years ago (Central Statistical Office figures, May 1991).

And yet Britain faces severe housing problems, both of quality and of quantity. These only beset a minority, but for those who suffer them the misery can be just as acute as in the slums of Bombay or São Paulo.

In colder countries more time is spent indoors. And increased affluence means everyone spending more time at home: the working day becomes shorter and so does the working week; holidays get longer; and more years are spent in retirement. More people work from their homes and more of their entertainment and leisure hours are spent in the home. To have no place to go, or to live in insecure, damp, cold, or overcrowded conditions, causes particular hardship in a country like Britain. And the cost of curing the social problems which follow from inadequate housing provision places a major burden on the whole community.

2.2.1
The problems in Britain

In terms of quality, the number of homes unfit or in 'serious' disrepair remains stubbornly high, despite higher standards for the rest: the figures, standing at around one million homes in each category out of a total stock of over 21 million, have changed little in a decade. At the same time, there have been calls—led by the authoritative Audit Commission (1986)—for more work of improvement and repair to the housing stock of local authorities, much of it built using industrialized 'system building' techniques in the 1960s.

Yet demolition of residential property has gone out of fashion: from 70000 homes demolished each year in the 1960s, to a level that still exceeded 45000 in the late 1970s, the figure dropped through the 1980s to around 8000. From this comes the unlikely statistic that every dwelling in Britain today will need to last over 2700 homes!

At the same time, Britain faces acute housing shortages because of a decline in the number of new homes built each year. The fiercest demand is from those on low income waiting for rented accommodation. House building is currently in recession: completion of new homes (in the private and public sectors together) seems likely to be at its lowest level since 1947 (Housebuilders' Federation estimate, May 1991) and this is compounding the problem created by the demise of development by the municipalities. By 1991 the output of housing built by local authorities has fallen to levels not seen since these became significant housing providers after World War I. Spending on new building has fallen from over £4.5bn pa in the mid-1970s to £0.5bn pa in the early 1990s (Niner and Maclennan, 1990).

At the same time, investment by the private sector in the construction of new housing for rent has been minimal for 50 years. A legislative and financial framework has favoured home ownership and deterred private investment in the rental sector. When provision by public bodies—in Britain, the local authorities—is dramatically curtailed, the result is a shortage of homes for those who cannot buy.

With the number of new households—not least those created through family breakdown and from younger people leaving home—rising through the 1980s, it is not surprising that the fall in house building for rent meant substantially more homelessness. The numbers of families accepted as 'statutorily homeless' — i.e. finding themselves with nowhere else to go and judged to be priority cases, and in these circumstances unintentionally— doubled between 1980 and 1990. The numbers occupying temporary, often appalling, accommodation in hostels and 'bed and breakfast hotels' increased by 200% during this decade. This phenomenon was by no means confined to London: a rising proportion, currently about two thirds, is found outside the capital (Hills, 1991a).

2.2.2
The causes

The Inquiry into British Housing, chaired by the Duke of Edinburgh, reported in 1985. It has subsequently reviewed its conclusion and a Second Report will be published in the summer of 1991. This investigation concludes that the factors lying behind Britain's housing problems have been inadequate investment in rented housing, and a heavy financial bias towards owner occupation.

As the central cause of these difficulties, this Inquiry identified an unhelpful and rigid financial and organizational framework.

While house building for rent has slumped, support for home ownership has been sustained. Britain has the largest percentage (between 75 and 80%) of owner occupiers under the age of 30 of any industrialized Western country (Greve and Currie, 1990). Owner occupation increased in the 1980s in Britain from 54% at the end of 1979 to 66.6% at the end of the 1989 (and is estimated to have carried on upwards to 67.8% by the end of 1990). About half of the new owners during the 1980s were council tenants taking advantage of a statutory 'right to buy' their homes at a large discount.

This emphasis on owner occupation has been underpinned by special tax privileges, principally the opportunity to set mortgage interest against personal taxation (to a limit of £30000 per property) and freedom from all capital gains tax (on the profit made on the sale of a principal residence).

This dependency upon the encouragement of home ownership to provide for Britain's housing needs has created escalating problems. Those who cannot afford to buy a home of their own have faced a shrinking supply of rented accommodation. Meanwhile, the home owners themselves have been vulnerable to economic circumstances, not just if they lose their jobs. The number of households getting into mortgage arrears escalated as interest rates rose rapidly in the late 1980s. Mortgage default was the reported reason for homelessness in about 10% of all cases.

As well as imposing strains on the budgets of British households, reliance on owner occupation has also created inflationary problems and difficulties for job mobility, both of which affect the nation's productivity and wealth.

I now consider the prospects for Britain's housing in the decades ahead.

2.3
POLITICAL TRENDS

2.3.1
Global political trends

Political debate on housing questions has been typified in Britain, as else-where, by acceptance or rejection of the role of market forces on the one hand and of state intervention on the other.

The construction and provision of houses can be left to the hidden hand of market forces; or governments, at the local or national level, can intervene to provide housing. Within industrialized societies, these broad approaches might best be exemplified by the United States, on the one side, and the countries of Eastern Europe on the other. The former has seen little role for the state as a housing provider and put its faith in the market; while since 1945 the latter have produced the majority of their countries' homes through provision by agencies of the state. These two extremes illustrate some of the hazards of both approaches.

In the United States, every major city suffers from substantial tracts of low-quality housing, occupied by the poorest families and frequently both unsightly and unsafe. The black communities—both African-American and Hispanic—are concentrated in these neighbourhoods. Public housing, seen as 'welfare provision', is itself undesirable and hard to manage; it is very common for the public authorities to employ armed personnel for these estates. The number of properties provided directly by public authorities comprises only 1% of the total stock. Meanwhile, subsidies to individuals to help them pay for accommodation in the private market are so severely rationed that only one family in six eligible for such support actually receives it. Efforts to subsidize private landlords, through various forms of tax sheltering, have had limited success; only another 1% of properties are available on these special terms and many of these are not within the price range of those with the lowest incomes. Houses that have been the subject of tax concessions, but are no longer of financial benefit to their owners, have been abandoned in many major conurbations.

The result of this dependency on market forces in the housing field is visible throughout the USA with undesirable results for the least affluent 10–15% of the population. Supporters of the system, however, would point to the satisfactory housing for the majority and to the wider value of visibly unpleasant conditions as an encouragement to all to work harder (Grigsby *et al.,* 1990).

In contrast, the Eastern European countries have relied upon the state to supply the finance and build the homes for the majority of the population. Large-scale slum clearance and redevelopment (and postwar rebuilding of devastated urban areas) has achieved accommodation at a basic level, irrespective of income, for most citizens. However, the services of management and maintenance have been fiercely criticized by the residents, arrangements for allocating the best homes have often been subject to local patronage (with many reported cases of corruption), and the architectural and building standards have frequently been abysmal. Vast, impersonal concrete estates have proliferated with a low quality of life for very large numbers. These estates, while usually safer, have frequently proved as dismal as that of their American counterparts (Emms, 1990).

In the next century, the lessons of these ideological experiments are likely to be learnt and, throughout the industrialized world, the more extreme policies seem likely to be moderated. As less developed countries become more urbanized, they may benefit from the failures of those who have gone before.

2.3.2
British political trends

In Britain, these two political perspectives on housing have had their adherents. After World War I, when it was deemed necessary to build 'homes fit for heroes' on a large scale, public sector housing began to expand: 'Threatened with industrial dislocation and social unrest, both Cabinet and Parliament accepted the housing programme of 1919 as the necessary price of social stability, the unavoidable premium of the "insurance against revolution"' (Swenarton, 1981).

Local authorities were the chosen agency to built affordable homes up and down the country. Not-for-profit organizations—charitable bodies, housing cooperatives and mutual societies—were too scattered and small scale to be the main instruments for government intervention on the housing front. Again, after World War II, it was to the municipalities that the Labour government turned for the production of rented homes. While letting the private sector operate exclusively in the field of building for sale, the state took on the role, through a succession of financial incentives and legislative measures, of providing the rented housing.

Rent controls and security of tenure meant that profit-making landlords sold up whenever they could and have built virtually no new rented accommodation in Britain since 1945. While market forces handled the owner-occupied sector, politicians relied on the public sector for the flow of homes to rent (Lowe and Hughes, 1991).

By the early 1970s some doubts were being expressed on the division of Britain's housing between these two sectors. As the private rented sector continued to decline, and virtually all new development for rent was undertaken by the local authority in each area, anxieties emerged about the monopoly held by the council landlord in each locality. The position could be envisaged in which all those with income too low to afford home ownership would be required to obtain their accommodation from one provider, the municipal landlord, for each area. At the same time, dangers were noted of impersonal management, and inefficient delivery of services, from a supplier which not only had no competitors but which was operating on a large—and consequently often a distant—basis. To provide some diversity and variety, ultimately to give tenants some choice, the Conservative and Labour governments of the mid -1970s decided to promote the rapid expansion of the third sector, the not-for-profit housing associations. These could compete for public funds and inject a level of flexibility because of their relatively small scale; not only could they fill the gaps left by the major provider, the local authority, but they could bring new ideas and innovative methods to the provision of rented homes.

The origins of British housing associations are in the charities which date back to the first millennium. Philanthropists in the 19th century boosted development by non-profit bodies before the concept of council housing took root. Their origins lie also in the self-help Co-operative Movement of those who wanted to provide collectively for their needs. The desire for home ownership channelled much of this spirit of cooperation into the mutual building societies which financed the construction of owner-occupied homes for their members; today these same societies are mighty financial giants. But the number of housing associations building for rent, despite cross-party support, has remained small.

The 'Thatcher years' were characterized by, among other factors, efforts to diminish not just the spending but the power of local authorities. They were also a boom time for home ownership; the philosophy of a 'property owning democracy' was stimulated in new ways. The most direct switch from public to private ownership came with the right-to-buy transforming over one million council houses into owner-occupied property, using discounts of up to 70% off the market price.

Political intervention to roll back the frontiers of the state in housing also took the form of giving council tenants a statutory right to change the ownership and management of their properties. Tenants have proved extremely reluctant to use this new collective power. The elected councillors and their housing managers, who have resisted this concept, have constant access to tenants who are either content with the service they receive, or favour 'the devil they know'.

But by increasing controls upon local authorities, and offering the release from these through the sale of their property to other landlords, the government has persuaded some councils voluntarily to pass over ownership to housing associations (most of them newly created for the purpose). So far this process of 'voluntary transfer' has only covered about l½% of the council stock. By 1990, the same proportion of the total rented sector in Britain, about 70%, was owned by the local authorities as had been the case at the outset.

2.4
THE OUT LOOK FOR 2000 AND BEYOND

In the 'post-Thatcher years', the signs are that politicians of all persuasions are now reaching a broad consensus on the ways of overcoming some of Britain's continuing housing difficulties. These lead to a number of predictions.

2.4.1
Ending owner occupiers' privileges

By the early part of the next century, the privileges for the owner occupied sector will be curtailed. Mortgage interest tax relief will be phased out, despite a political horror of removing a system perceived by the majority of the electorate as being to their advantage. In reality, the mounting cost of this subsidy-which means the Treasury currently having to forego some £7 bn pa, rising to over £9bn by the mid -1990s if left unchecked—is inequitable since it gives most help to those able to afford the maximum eligible mortgages, and provides nothing for poorer home owners; it is also ineffective in helping first-time buyers to break into the market because it gives them no special assistance. Indeed, since the value of the tax relief is largely capitalized into house prices, it makes purchase more difficult for the first-time buyer, who has no other property to sell. Britain's over-emphasis on owner occupation also has effects on the wider economy, which I discuss in the next section.

While in other countries the benefits of mortgage interest tax relief are often counterbalanced by property taxes (or taxes on 'imputed rental income'), no such taxes exist in Britain. From 1990, the local 'rates' were replaced by a 'community charge' unrelated to the value of the home.

However, the position is changing dramatically. The 'community charge' is to go and a new local tax linked to property values seems certain, irrespective of whether a Conservative or Labour government is in power. Moreover, the present government has announced the abolition of tax relief at the higher rate, confining it to the standard rate tax. These changes are the start of a process which will diminish the unhealthy financial bias toward owner occupation.

2.4.2
Deregulating private landlords for the better-off

Despite the Labour Party's deep-seated dislike of profit-making landlords, it is likely that some of the recent changes by their opponents in deregulating rented housing for new (but not existing) lettings, will become acceptable. At the upper end of the market, the consumer has the resources to shop around and government interference seems out of place. Although every politician knows that more voters are tenants than landlords, the preventing of private sector companies or entrepreneurs from obtaining an adequate return leads simply to the market drying up. With a more 'level playing field' in the treatment of owner occupation and rented housing, private renting could produce profits once again and, thereby, cater for those moving for job reasons or moving in retirement into the less burdensome tenure of renting.

2.4.3
Making better use of personal subsidies

Continuing political conflicts can be expected over the housing of those on lower incomes. Here, a deregulated private sector is not likely to be acceptable to those to the left of centre. If people with low incomes or no incomes are to have decent accommodation, they must receive housing help in cash or kind.

'Producer subsidies' —to state agencies, independent housing associations or private providers—can pay directly for new or improved homes and ensure the price is affordable to those on low incomes. But they represent a 'top down' form of support which cannot be relied upon to produce what the consumer really wants. In recent years lessons have been learnt about subsidies to producers from Eastern Europe's production of unwanted consumer goods, and from Western Europe's over-production of butter, beef and other agricultural produce. Targeted subsidies to individuals make the most efficient use of the available money. But in housing, it can take a long time for supply to be generated and housing built as a result of subsidies being given to individuals. With rising homelessness, politicians realize that the country cannot wait. Moreover, a system of subsidy to individuals, coupled with deregulation of rents so that landlords can make adequate profits means most low-paid workers becoming dependent upon the personal subsidy (currently a housing benefit). They face a poverty trap in which most of any extra income they earn goes to reduce the housing benefit (National Federation of Housing Associations, 1985; Joseph Rowntree Foundation, 1991). For these reasons, a balance between producer subsidies and personal subsidies seems necessary in the immediate years ahead.

In 20 years from now, if supply can be increased, if privileges for home ownership are phased out, and if real incomes of tenants rise, private landlords may be able to operate in the market place, accommodating those with no incomes or low incomes. The very poorest would need personal subsidies (housing benefits) but most of those in full-time employment would be able to afford the rent from their own resources. There could then be choice for the consumer, who could shop around in a competitive market. The dissatisfied tenant could move elsewhere, or negotiate a rent reduction.

2.4.4
Using a variety of providers

Given that some producers will need to be chosen by the politician to provide the 'bricks and mortar' subsidy (until personal subsidies alone can work), it seems probable that the concentration on local authorities, which has characterized the 20th century, will not be repeated in the 21st.

Conservatives can point to the private sector's success in the field of home ownership. But if government opts for the provision of subsidies to a scatter of profit-making landlords, difficulties seem inevitable, of policing the public funding, of ensuring value for money, and of maintaining public confidence. And it is uncertain whether such landlords would be willing to invest the large-scale resources needed for the development of property while fears remain that a change of government could mean all this money was put at risk.

The Labour Party can justifiably point to the success of council housing. But politicians on the left are not blind to the deficiencies of a policy which can lead to inertia, inflexibility and insensitivity to consumers if one provider holds a virtual monopoly of an area's low-cost housing.

The compromise, which has long been advocated by the parties of the centre, is to make greater use of the not-for-profit housing associations. These can provide variety and flexibility, competing with each other for available public resources and capable, unlike the local authority, of going out of business if they fail to handle their affairs effectively. Yet such bodies can be supervised and monitored by the state, while their non-profit motivation and the potential for tenant involvement add qualities with widespread political appeal.

One use for the housing association model in Britain is in absorbing the landlord role for local authorities. The Duke of Edinburgh's Inquiry, among others, has emphasized the strategic role of each local authority as co-ordinator and enabler, rather than principally that of provider/landlord. The role of landlord itself, with the agreement of the tenants concerned, may be better undertaken at one remove. Recent lessons show this change cannot be achieved through confrontation, but the municipalities can be persuaded to transfer their estates to newly formed housing associations if incentives are in place.

It can be predicted that in the next century, the dominance of municipal ownership of rented housing in Britain will change. While many local authorities will wish to retain a landlord role, it can be expected that the balance will shift and a variety of newly formed and existing housing associations—together providing tenants with real choice, and providing each other with the benefits that flow from a more competitive environment —will account for the bulk of subsidized housing provision.

In some of the other countries of Northern Europe, this third sector— seeking to combine the best of the public and of the private sectors—has already prospered. Today's 'voluntary housing sector' in Britain is now building more new homes than local authorities as well as being the recipient of transferred council housing. It is increasingly combining its charitable origins and its self-help roots. This broader, pluralist provision of the 2000s may provide models for others wrestling with the conflict between the influences of Adam Smith and Karl Marx, between leaving housing to the market place or providing homes through state organizations.

Some will predict that the conflicts in Britain between left and right are bound to be moderated by greater 'Europeanization', with a greater uniformity of behaviour between the United Kingdom and other members of the European Community. As an adjunct to this, some expect a system of proportional representation to be introduced within the next decade or so. This would tend to soften the political extremes. Either or both of these trends would reinforce the cross-party moves toward a 'social market', a pluralist approach to housing provision, with a reliance on private enterprise for the majority but state aid for the minority channelled principally through a range of not-for-profit organizations.

Those in Eastern Europe and the USSR may find models in the not-for-profit housing organizations which are separate from the apparatus of the state and yet avoid some of the dangers of the fully privatized market; those seeking solutions to the huge problems of homelessness and 'housing poverty' in the USA, may find ideas here for governmental support along-side private investment in local organizations of the housing association kind; and those countries achieving new levels of prosperity may note the pitfalls of dependency on either owner occupation or municipal house building.

2.5
SOCIAL TRENDS

Many of the ways in which society is changing in Britain have an impact upon housing. 'Fewer babies' means smaller households and, in time, fewer new households; 'longer lives' means less turnover of property and a greater demand for smaller, more manageable homes; rising divorce rates mean households dividing into two and increased demand for accommodation; and the greater independence of younger people means more leaving their parental home sooner and adding to a requirement for housing. Most of these trends are shared with other European countries and since they all seem to bear a relationship to rising wealth, the same trends may affect many other countries in the next millennium.

Demographic changes are often predictable since many are determined by events which have already occurred. In Britain, regular forecasts are made by the Office of Population Censuses Surveys and this section uses the estimates from that source to consider their impact upon housing.

2.5.1
Fewer babies

In the 1960s, Britain experienced a 'baby boom'. But since 1974 the birth rate has remained below the level needed to replace the population; it is currently about 1.8 children per woman. Fertility fell in France and the US A in a similar way and also, from a lower base, in Germany; Italy followed in the mid-1970s and the pattern has been repeated in Greece, Portugal and Spain. It seems that among the reasons for these trends, contraception—particularly through the contraceptive pill—has reduced unwanted and unexpected births; a shift in employment opportunities toward the type of jobs generally taken by women, has led them to postpone childbearing; and a rise in prosperity has given people more opportunities to spend their money (e.g. on travel and leisure activities) which provide alternatives to parenthood (Ermisch, 1991). Specifically in relation to housing, one study indicates that high house prices discourage women from starting a family and also reduce the probability of a second birth among mothers in their early twenties (Ermisch, 1988).

In the 1980s, the children of the baby boom reached the age when they formed their own separate households. During this decade, therefore there was an accelerated growth in the number of households. But the effects of this are largely played out by the early 1990s and it can be rationally predicted that the number of new households will fall steadily during the next decade; although it is likely to rise again between around 2002 and 2012, it will only reach half the level of that experienced in the late 1980s. And thereafter, in the second and third decades of the next century, assuming the present low levels of fertility are sustained, the number of households will fall again, with the effect that after 2025 there will be an actual reduction (OPCS, 1989a).

The implications of this demographic change on housing are likely to be very significant. In 1989, the growth in new households from the maturing of past generations created a demand for about 165000 extra homes. This compares with the building during the 1980s of an average of about 200000 homes per annum (by the public and private sectors combined). By the early 2000s the demand for new houses from these new households will be down to about 40000 homes; and by 2025, there will be no demand at all from this source.

This is not to say that the need for the building of new homes will dry up. The other social trends outlined here will play their part. And the backlog of producing too few houses in recent decades means there is a good deal of catching up yet to do. Nevertheless, population changes in Britain are bound to moderate demand for housing, reversing some of the recent pressures on house prices and, eventually, dampening activity by the construction industry.

2.5.2
Longer lives

Deaths are now occurring at much later ages than they did in the past. Life expectancy for women in Britain is now 77.7 years compared with 71.9 for men (Home Office, 1986). Medical advances mean that many more people are living past the age of 85: over a third of women and over 15% of men. No doubt this longer expectation of life has been assisted by more adequate state and private retirement pensions.

An increase is forecast in the 60–64 age group, with relative stability for those aged 65–79, and a 26% growth in the numbers aged 80 or more by the year 2010 (to 600000 people).

These changes reinforce the demand for smaller homes. They also imply movement out of family-sized accommodation into one- and two-person housing which is tailored to the needs of less mobile occupiers. Britain is well provided with three-bedroom houses, which represented more than half of the house building programme up to 1980. If a large proportion of Britain's homes are not to be under-occupied, not only will new building need to concentrate upon houses and flats with one and two bedrooms, but existing property will need to be converted to provide more units. At present it is common for larger Victorian terraced houses to be converted into flats but only a tiny proportion of the council houses and suburban private development of the inter-war years has received this treatment. If it becomes acceptable for these single properties to be made into two homes, on an extensive scale, there will be a further reduction in the need for new homes, but more conversion work by the building industry.

No account has been taken in this analysis of the impact of Acquired Immune Deficiency Syndrome (AIDS). Forecasts of the impact of AIDS have varied dramatically (between the OPCS, the Institute of Actuaries and the Public Health Laboratory Service). At present the best guess is that even if no new cure is forthcoming soon AIDS will not make a significant difference to mortality rates in Britain. But this optimistic forecast could be proved wildly wrong.

2.5.3
Stable divorce and separation rates

Divorce rates doubled in the 1970s, from a rate of 6 per 1000 marriages to 12 per 1000 marriages; figures have remained roughly constant during the 1980s and if they continue, then 37% of marriages are likely to end in divorce (affecting 1 in 5 children under the age of 16). (Nearly 70% of lone parent families are the result of divorce and separation; 23% are headed by never-married mothers and 8% by widowed mothers (Haskey, 1989).)

Taken alongside the relatively small number of families headed by a widow, and those households where the mother has never married, Britain has a high proportion of lone parent families; at about 14% of the total (which is not far removed from the majority in Northern European countries, but about twice as high as for the countries of Southern Europe) (Roll, 1989).

Because only around 50%, less for women, more for men, of divorcees marry again within five years, the effects of relatively high divorce rates have put pressure on the housing market. A recent study indicates that 80000 new homes are needed every year to keep up with the demand created (Holmans, 1990). Moreover, this form of demand can usually be satisfied only by an increase in relatively low-cost housing for rent; divorce leads to a marked slippage out of owner occupation (and, for both partners, to less satisfactory housing) (Walker *et al.,* 1991). This trend continues to have important effects on the housing market. However, divorce rates now seem stable (although statistics on the separation of cohabiting households need more analysis) and it is not predicted that this trend will contribute major change to the housing scene in years ahead.

2.5.4
More young people leaving home

It is more difficult to forecast trends in young people leaving their parental home. On the one hand, with the declining numbers of young workers aged 16 to 24—falling from over 22% of the population to less than 17% of the population between 1987 and 2027—employment prospects for this age group will improve. Past behaviour indicates that the desire for independence translates into young people forming their own household as soon as they can afford to do so. But the skills shortage in Britain, which is leading to a new emphasis on further education, may postpone the moment at which young people have the resources to leave home, other than as students. On balance it seems possible that an increasing percentage of young people will form their own households, either on their own or with a partner and this could moderate the influence of purely population-linked changes on housing demand (Ermisch, 1991, p. 39). With the smaller numbers involved, the impact of this pressure on the housing market may be muted. But, again, it is likely to be the smaller homes which are required.

2.5.5
Uncertain migration patterns

In recent years immigration into Britain has only been slightly more than emigration out of the country. The greatest movement has been in and out of other member countries of the European Community (compared with the largest flows in the 1970s being in and out of Australia and New Zealand) (Policy Studies Unit, 1991, p. 129).

The OPCS forecasts that there will be no net migration to or from the UK (but some inward migration to Great Britain from Northern Ireland) for the 40-year period 1987–2027 (OPCS, 1989b). But forecasts here are inevitably speculative. The tight labour market could lead to European countries behaving more like the USA in drawing in unskilled workers; such a trend could be accelerated if Turkey with its population of 60 million rising quite rapidly were to join the EC (Ermisch, 1991, p. 35).

But other forecasters have made contrasting predictions. Michael Harrison (1991) from the University of Sheffield says: ‘It is inconceivable that mass starvation at latitude 10° North and over indulgence at latitude 50° can co-exist for much longer—world communications quickening as they are— without the inhumanity of the contrast provoking an explosion of some sort. It could take the suppressed form of the long, slow burn that results in large scale migration from South to North, as is already happening to some extent from North Africa to Italy and other parts of the Southern shores of Europe.’

Inward migration clearly has an impact on housing. Tensions were created by the migrants from the British Commonwealth who came to Britain in the 1960s and early 1970s. Steps were taken to stem the inflows from these countries—principally from the Indian sub-continent—and now they mostly comprise dependants of earlier immigrants (Home Office, 1990). If there was further migration from the Third World upwards through Europe, perhaps encouraged by the labour shortages in the younger age group, this could clearly put pressure on the housing market, boosting the demand for low-cost rented homes.

On the other hand, it seems that the advent of the Single European Market will be slow to make a difference since there are few restrictions on movement between the EC countries at present. Those moving from Southern to Northern Europe in search of higher living standards may choose countries other than Britain. And the changes in Eastern Europe seem more likely to affect the countries adjoining these states, especially Germany.

There is a correlation between house prices and emigration; it may be that if house prices in Britain remain high compared with those in other European countries, the trend will be for those seeking better value for money to leave. Since the ratio of house prices to incomes is higher than in most of these places, housing seems less likely to be a motive for immigration from continental Europe.

Another uncertainty relates to the future of Hong Kong. It seems possible that there could be extensive immigration by the end of the century from that source. The recent trend has been for the Chinese emigrants to go particularly to Canada, not least because housing represents better value there. But if the volume swells after 1997, Britain will clearly be targeted. These immigrants will be likely to be well-qualified people with professional and business skills. They, in turn, might take the places of those with the highest qualifications who leave Britain for the United States and, perhaps increasingly in the next century, for Europe.

Taken together, perhaps the most reasonable assumption is that, in the next century, some of the ‘top people’ with skills to sell, could move away, easing demand a little at the higher end of the housing market. But that labour force requirements will mean rather heavier pressure for low-cost housing to accommodate new immigrants. The latter, if their move to this country is permanent, seem likely to require rather larger homes, perhaps absorbing some of the family housing in the public sector which could otherwise be in less demand.

Countries around the world may note the consequences for housing of these social trends. At first, falls in population are not likely to lead to less demand for housing because elderly people live longer and occupy homes for longer, and an increase in household formation can be expected from divorce or separation and from more young people leaving home. But the latter factors stabilize in time and the uncertainty centres on migration trends. Net inward migration, to meet shortages in the labour market, may compensate for the fall in household formation, boosting demand particularly for low-cost rented homes. A fall in property prices is possible in Britain, not least if there is an outward flow of more affluent home owners to Europe and the USA.

2.6 ECONOMIC TRENDS

Over the past two decades, Britain's gross domestic product has risen by about a half; over the past three decades it has nearly doubled (Central Statistical Office, 1990). Projections for the economy to 2010 were prepared by Cambridge Econometrics (linked to Cambridge University) for the Policy Studies Institute (1991, p. 261); these estimate that gross domestic product will be slightly more than one half greater in 2010 than in 1990, averaging 2.3% a year (which is marginally faster than in the period 1979– 90, substantially faster than in 1973–79 following rises in oil prices, but considerably slower than in the 1960–73 period). This extra wealth will find its way into housing in Britain; and, in turn, housing itself will have implications for the national economy.

2.6.1 Housing in the national economy

In Britain the construction industry employs close to one million people. Investment in housing is a fifth of gross investment in fixed capital and contributes over 4% of national output (Maclennan *et al.,* 1991, p. 5).

Because of the scale of spending on housing, this part of the economy can be used by government to stimulate employment, by public expenditure on construction, or to tackle inflation by spending less directly or by hitting the consumer through higher interest rates.

In this chapter I have predicted rather more expenditure on renovating down-at-heel housing and of boosting production of affordable rented homes. Although this scenario does not involve increases in house production for sale over the levels of recent years, it does mean more expenditure overall. This could give a modest stimulus to the economy.

2.6.2 Macro economics of home ownership

In relation to inflationary pressures, it has recently become apparent that the rise and fall of house prices has a widespread impact. It has been shown that there was a direct link between the consumer boom of the late 1980s and the rise in house prices over the same period (Muellbauer, 1990). Predictions by the Bank of England and the Treasury—for example in expecting a reduction in consumer expenditure after the October 1987 stock market crash— failed to recognize that the link with housing wealth was the real drive behind extra spending. But this is now acknowledged (Treasury, 1991).

Home owners draw out equity as property prices rise by borrowing on this security, or by trading down and releasing cash, or by selling up (if they go into residential care or emigrate) or by passing it on when they die. Probably of equal significance, if home owners feel richer because house prices have gone up, they are likely to spend rather than save, and even to reduce their savings.

In the late 1980s, consumer spending—concentrated on imported goods with dire effects on Britain's balance of payments—flowed from the general increase in property values. Once government recognized this, higher interest rates were imposed to curb the boom. For those who borrowed the very most they could afford, the extra costs of higher interest rates not only reduced their spending but created real hardship.

In the 1990s and beyond, the experience of 'boom and bust' in British house prices will have an impact on economic policy. Governments will not wish to see these problems recur. Apart from their electoral unpopularity, they have had clear consequences for job mobility: some people cannot move in the early 1990s because they cannot sell, and others are reluctant to try until house prices rise again. And, most important of all, this housing-led inflation, in leading to the requirement for higher interest rates, has dire consequences for British industry.

Some of the reasons why property prices surged in the late 1980s are unlikely to be repeated in the years ahead: easier borrowing has now made its mark and any backlog in demand has been soaked up; the bulge in new households is over; rises in real incomes are less certain; and some of the more enthusiastic lenders now appreciate the limits to extending credit for home owners. However, there are new factors, like the impact of lower interest rates likely to follow UK membership of the European Monetary System, which could work the other way. If the balance swung toward another boom, the dangers of highly inflationary consumer borrowing remain real: the net value of housing assets in the UK remains in excess of £700 billion against which massive further lending could be secured (Maclennan *et al.,* 1991, p. 20).

2.6.3
The future of owner occupation

These economic factors will underpin the political directions outlined earlier in this paper: the removal of tax privileges for owner occupation and a more neutral tax regime between owned and rented housing is likely. This should remove some of the artificial stimuli to house prices and more rental housing would prevent unwise property purchase.

Because so many younger householders already own their own homes, the percentage of owner occupation will grow as older tenants die: the sector is likely to expand from its present level of 67% of all homes in Britain to between 70 and 75%. But the political and economic trends noted here indicate that the rapid expansion of new owners is over.

2.6.4
Increased spending on the home

It can be safely predicted that the increase in real wealth forecast above will find its way, at least proportionally to other sectors, into housing. There are no limits to the potential consumption of housing. The occupier of a flat may want a house; the owner of the semi-detached house may want a detached one; those with three bedrooms want four or five; higher quality fittings or a larger garden or simply a more beautiful building. A house can display wealth or taste or character; even without extra tax advantages, it can be regarded as an investment. So in Britain, and no doubt in all societies, spending on the home will rise at least as much as spending generally.

Technological advances will present new opportunities for expenditure on the home. Already it is clear that security devices will be a priority for increasing numbers. It also seems likely that, with the home as the base for so much extra leisure time, extra facilities—from the gymnasium and the swimming pool, to in-house entertainment—will attract the consumer.

2.6.5
Spending housing capital on care

The owner-occupied home is not only the basis for two-fifths of borrowing in Britain; it also represents half of the national wealth of British households. It is the place where most people store the larger part of their personal wealth. (Maclennan *et al.,* 1991, p. 5). As an alternative to passing this on to the next generation, it can be used to finance the kind of housing and care which an ageing population is certain to need.

In the next century, it is very likely that 75% of the housing occupied by people at the moment of retirement will be owner occupied. In most cases, these owners will have paid off the bulk of the costs of the property. However, many of these older people will be ‘capital rich but income poor’. Their wealth is tied up in their home and they cannot use it. A recent analysis indicates that up to 39% of the pensioner population may fall into this category of ‘not rich, not poor’ (Bull and Poole, 1992). This number is set to increase.

How can the resources tied up in owner-occupied property meet the national need to support an ageing population in the third millennium?

Retirement housing

The collapse of the property market has temporarily slowed the trend of the 1980s toward the building of ‘retirement apartments’. Once greater stability returns to the housing market, more of these purpose-built developments should make business sense as well as providing the means to free under-occupied houses and provide elderly people with easy-to-manage homes. Perhaps by moving to lower-cost areas—e.g. from the Southeast to the North—home owners should be able to draw out some of the equity at the same time as better satisfying their housing needs.

Shared ownership

Sometimes the owner occupier’s home will not raise sufficient money to purchase a suitable retirement flat; and sometimes, even if it does, the occupier will wish to draw out a capital sum at this stage. Schemes of ‘shared ownership’, whereby elderly people acquire a lease for a proportion of their new home’s value and pay a rent on the remainder, can meet this need.

Flexible tenure

An extension to the shared ownership concept provides the opportunity for the occupier to sell back to the freeholder slices of the equity they hold, right down to the point of becoming a tenant. This provides the opportunity to withdraw capital without moving home in a way that is normally impossible for owner occupiers. This same arrangement has a very helpful application for younger households who run into difficulties in keeping up their mortgage repayments.

Extra care and loan stock

Use of capital to acquire equity is not appropriate for those elderly people who need to move into a residential home. But the acquisition of loan stock in the organization providing the accommodation can achieve a similar end: the money so invested can be used to rebate the fees in a tax-efficient manner.

Continuing care communities

In the United States, there are a number of 'retirement villages' providing accommodation for sale, coupled with a central complex containing facilities and a residential care/nursing home. Incoming purchasers can acquire, in one lump sum, both the lease on their flat or bungalow, and an insurance policy to cover the cost of any residential or nursing facilities which they may need later on. This combination of payment for housing and payment for care can give the residents—and their next of kin—much peace of mind.

The Joseph Rowntree Foundation in York is planning or undertaking projects of each of these kinds (Best, 1991).

2.6.6
Competing for space

The percentage of the value of each property which is attributable to land rose in the UK from under 25% to some 40% during the 1980s (Department of the Environment, 1989).

One reason why land is so expensive, it is argued, is the artificial scarcity created by planning restrictions. More liberal planning policy, so the argument goes, would be beneficial in reducing inflated land values. On the other side, economists point out that high land prices may be the consequence, not the cause, of high house prices: only 10–15% of houses purchased each year are newly built so it is the vastly larger second-hand market which sets the prices. And planners argue that they are willing and able to allocate sufficient sites each year to cater for known demand.

Whatever the merits of these arguments, it seems likely that conflicts will grow over where new homes should be sited in the next century. Hopes that the extra house building can all take place on derelict urban land fail to recognize the huge costs of reclaiming polluted sites—rather than turning them over to green spaces—and of the problems in adding to congestion in built-up areas. But in Britain's countryside, local opposition to new building will be vociferous: fears centre on the possibility of the views from the home being spoilt or property prices being adversely affected. In a democracy, the strongly felt views of the well-housed majority are likely to prevent homes being built for those who need them but who are not currently living (and voting) in the area. The NIMBY (Not-in-my-back-yard) phenomenon seems destined to become more prevalent with the most vocal opposition to further development coming from relatively recent newcomers.

In most countries throughout the world, including most of those in Europe, the problems of rural areas are about the poverty of people in relatively remote places, often following the decline of agriculture as the major employer. But in Britain, the problem flows from affluence. The more recent arrivals are the urban middle classes who want homes for retirement, or as second homes and holiday homes, or for commuting to towns and cities nearby. These people have priced out the sons and daughters of the indigenous population who themselves must move away. Only a residue of poorer and often older local people will eventually remain (Best, 1990).

In other countries, those currently less densely populated than England, these issues will emerge as shortage of space becomes a growing concern.

2.6.7
New settlements

It is clear that the major contribution made by the building of complete New Towns, which followed the earlier Garden Villages, represent a scale which it would be hard to replicate in this crowded island, in the next century. But that form of development remains an export from Britain which still has application in the open spaces of other countries. In a world concerned with reducing the pollution of endless commuting, the creation of settlements in which housing and jobs are close at hand, and in which environmentally friendly local transport can be installed, has much to commend it.

In this country, more modest concepts of the new settlement are taking root. Planning applications have been made for over 80 new villages. These are the successors to Joseph Rowntree's New Earswick, George Cadbury's Bournville and W.H.Lever's Port Sunlight. The new communities of tomorrow offer the opportunity for well-planned, well-designed villages. These could help ease Britain's shortages of affordable housing. They could also prove acceptable where both larger and smaller settlements are failing to get through the democratic processes, because they can fit into spaces where they have few neighbours.

The landowner can see that the price obtainable for his site will be far in excess of agricultural value; but because of the necessary requirements for social facilities and for low-cost housing, it will be well below the levels for development land in urban areas. This compromise on the price can make it possible for a model development to be built without the need for public subsidy (Darley *et al.,* 1991).

This paper has taken a broadly optimistic view of political, demographic and economic trends. However, it must end with an anxiety: despite increased affluence, and even on the assumption of more equitable subsidy systems, it seems possible that the next century could see poorer minority groups confined to the less desirable parts of the major conurbations. It requires a combination of regional and local planning, targeted public investment and a willingness by politicians to devote their energies to a potentially unpopular cause, to prevent a section of British society getting left behind. Low quality estates of 'welfare housing' can already be found both in inner city areas and on the peripheries of major conurbations. The key to uplifting such neighbourhoods may be to use the resources of the residents themselves: if their time and commitment can be harnessed, with backing from the rest of society, it may be possible to prevent these localities sinking further. And, coming full circle, this lesson of creating 'bottom up' new communities through the labour of the ordinary people, may be one which this country can learn from the Third World.

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3
The envelope of the house in temperate climates

M.Fordham

3.1
ENERGY: THE MAIN PARAMETER FOR THE NEAR FUTURE AND BEYOND

Fossil fuels are limited and their use causes pollution, but the growing population of the world continues to demand an increasing amount of energy, in particular, heat energy. We may develop other sources of heat energy. Nuclear fission does not produce carbon dioxide and we could possibly come to terms with its waste products. Nuclear fusion is still an extremely expensive way of producing energy.

If plentiful, non-polluting sources of heat became available, the large amount of heat which humankind might choose to add to the overall energy budget of the Earth would be negligible compared with the heat Hux from the Sun which reaches the Earth.

Renewable sources of work energy—of which wind and waves are examples—will provide high-grade work energy which will be needed for uses other than heating houses. Solar energy provides valuable light but the heat content is very small compared with what is required for buildings in cold weather.

Currently, about half of the fuel we consume is degraded to heat by passing through our buildings. At some time during the next millennium the growth in population and depletion of fuel will force buildings to change so that they use very much less heat then they do now. I assume here that minimizing the use of fuel-derived energy will be a central requirement for the housing envelope in the third millennium.

Buildings are still in use whose design evolved over 1000 years ago. Buildings designed in the immediate future are likely to be in use well into the next millennium. If limitless supplies of high-grade energy are tapped, then the buildings designed and built now to save fuel will still be usable. I examine the physics of the building envelope to see how it could be made to reduce the reliance on fossil fuels while maintaining the levels of comfort to which Western society has become accustomed.

Where the climate is temperate, i.e. avoiding the extremes of heat and cold, it should be possible to construct the envelope of a house so that a negligible amount of energy has to be used to sustain comfort, and as techniques improve, the range of climates which can be mastered with little energy use will widen.

The main factors which define the energy use of a building are (1) the level of lighting needed, (2) the amount of ventilation, and (3) the number of people in the building. Light levels in houses are generally lower than in most working buildings. The activities in a house seldom require intense light. In a house cooking, washing and cleaning generate water vapour and smells which need to be removed by generous ventilation. The number of people in a building controls the amount of ventilation and the amount of energy needed. Thus the parameters which distinguish housing from many or most other building types are the low demand for lighting coupled with the high demand for ventilation. The envelope has to provide means of admitting light and ventilation. At the same time it has to stabilize the fluctuations in temperature inside and control the flow of heat to the outside.

3.2
FLUCTUATIONS

The energy use in a house depends very much on human behaviour. At present variations in people's temperature settings, in the number of people living in the house, in the amount of ventilation that individuals choose, in the use of hot water, lighting, and machinery, all mask variations caused by, for example, the thermal insulation of the walls.

British Gas research shows that the best correlation for predicting gas used in houses is simply the number of people living in the house (Dench and Finch, 1973).

The ratio of maximum to minimum energy bill in a group of identical flats is likely to be 5. There is no correlation with the calculated thermal resistance of the building envelope. Any model of energy use must take this variability into account.

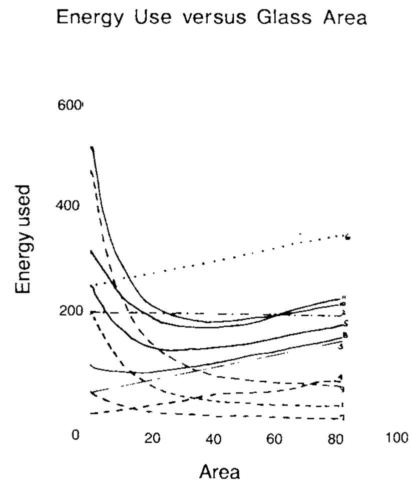

Figure 3.1 Energy use against glass area, showing that the lighting level makes a significant difference to energy consumption. (From Lewis, 1989.) (1) 300 lux, lights controlled; (2) 300 lux, lights always on; (3) heat loss only against glazing area; (4) air-conditioning load only against glazing area; (5) 300 lux, heating and lights controlled; (6) 300 lux, heating and lights always on; (7) 60 lux, lights controlled; (8) 60 lux, heating and lights controlled; (9) 700 lux, lights controlled; (10) 700 lux, heating and lights controlled; (11) 300 lux, heating and lights controlled and air conditioning.

3.3 COMFORT

There are various ways of achieving thermal and visual comfort. A large part of the variability in energy use referred to above is related to different people's choices relating to levels of comfort. To minimize energy use it is important that people learn to use individual task lights where high levels of illumination are required. Warm clothes should be used rather than raising the temperature setting of a thermostat. It should be possible to design flexible good insulating clothes for use in the next millennium. In temperate climates buildings should be comfortably cool during the summer. People can become accustomed to a temperature of 30°C as long as it does not get this hot too often.

3.4 LIGHT

Energy use depends on light. Recent work commissioned by the EC illustrates the relationship between use of energy and areas of glass in the envelope of a building. Fig. 3.1 illustrates the principle of the work. Energy use is primary fossil fuel, which in energy terms is represented approximately by electricity meter readings multiplied by a factor of 3.5.

Curve 1 is the energy used to provide 300 lux of light during office working hours in mid-coastal Europe. The lights are controlled so that only 300 lux is available. This implies progress. The shape of this curve depends on the orientation of the glass, the amount of daylight available, and the type and transparency of the glass. Curve 2 would apply if the lights were always on. Curve 3 shows the heat-loss due to ventilation and the opaque wall alone for zero area of glass. As the glass area is increased the energy used for heating tends to rise. The shape does depend very much on the external temperature, amount of sunlight, type of glass, or the use of insulating blinds. The slope can easily fall as glass area increases for many conditions, but large glass areas tend to lead to overheating in summer. Curve 4 shows how much energy may be used for air conditioning if applicable. Even if air conditioning is not anticipated a high cooling load indicates overheating in summer. Shades are likely to be needed. Curve 5 is the sum of heating plus lighting energy. The flat minimum in energy use gives a loose optimum for the glass area. It may be a coincidence that it corresponds vaguely with the pre-modern movement buildings. As we improve windows the minimum will move to increased areas of glass. Curve 6 shows what happens if the lights are always on. No windows are needed! Curve 7 is the light energy used to provide 60 lux. Curve 8 approximates to the total of heating and lighting obtained by adding curves 7 and 3. The lower light level means less energy and fewer windows. Curves 9 and 10 similarly relate to a high light level of 700 lux and demonstrate a high energy use associated with bright illumination. At the same time the optimum glass area is high. Curve 11 is the total energy used if air conditioning is taken into account at 300 lux. This line of thinking shows how the energy use and optimum window area are dependent on design light level.

The immediate question as to the required light level has to be addressed.

Figure 3.2 A cob cottage (from Taylor, 1972).

3.4.1 What light level?

There is well-established research into the relationship between light level and accuracy of seeing. Natural lighting levels should be higher than the recommendations so that the artificial lights are switched off when the natural light is adequate. There is comparatively little research which compares light level with other parameters of the building. Work carried out in the UK (Building Research Establishment, 1966) investigated people's response to light levels, overheating, and traffic noise. Buildings whose design has evolved give a clue as to the compromises which people have made.

When we consider the complex series of interactions which are summarized by the word 'architecture', it is helpful to look back a thousand or so years. A cob cottage (Fig. 3.2) provides a light level on an overcast day of the order of 100 lux. The design must have evolved at the beginning of the last millennium. It is still sought after. A thousand years ago it would not have been easy or cheap to admit light without also admitting fresh air. Glass in openings represents a real technical advance. An Arabian building (Figs 3.3, 3.4) must have evolved at the same time in very different conditions and also provides 100 lux most of the time when the sun shines.

As an engineer, I interpret these observations to imply that in the hot climate of Arabia and the temperate climate of the UK the compromise which society has evolved over a length of time, which I guess to be around 1000 years, leads to the same light level in these very different conditions.

The weaver's cottage (Fig. 3.5) is another evolutionary response, this time to the problem of a person working at a loom. The light level about a metre inside the building would be a minimum of about 1000 lux with an overcast sky. If the window were to the north it would then provide 2000 lux from a clear blue sky and probably as much as 3000–4000 lux from a lightly clouded glarey sky.

These observations point to the design compromises between constructional and economic needs and the need for light. More modern work on light levels handles the problem in isolation so that accuracy of visual tasks is related to light levels. For the third millennium we ought to maximize the use of natural light by means of efficient design. Since 1973–74, as a result of the oil crisis, recommended light levels have dropped slightly.

Light levels in houses are generally lower than light levels at work. Recent research (Lighting Research and Technology, 1983) shows that people are satisfied with light levels in housing at about the 100 lux level. Although I cannot find any reference in fiction to a person in a house wanting to read and taking a chair over to the window, I believe windows are used as task lights in houses.

People commonly need a light level of between 100 and 1000 lux depending on their activities. In the cloudy UK the optimum daylight factor for houses is likely to be about 2%. For 500 lux it would be 10%. The conclusion here is that on a conservative view of energy use there seems to be no reason for constructing large windows in houses to admit light. Most designers who work with an anglepoise lamp on their drawing board do set the lamp at a height which provides about 1000 lux. I know it dries the ink as well.

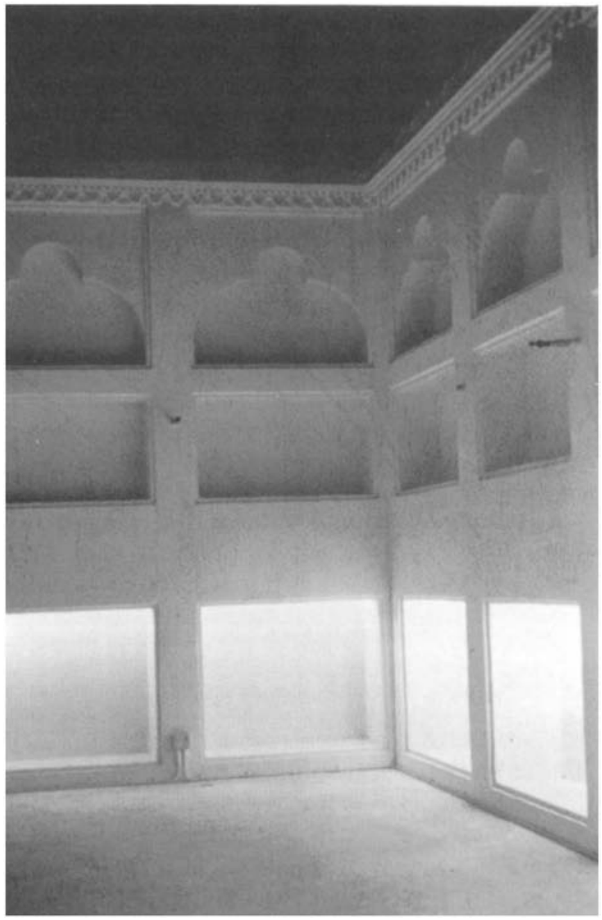

Figure 3.3 An Arabian building, exterior view.

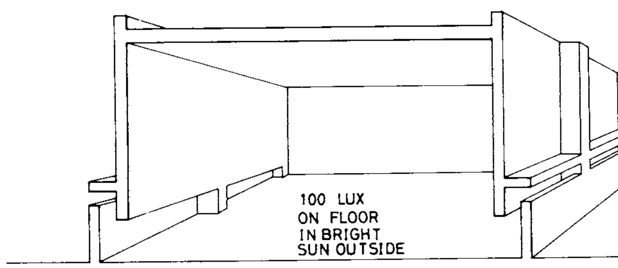

Figure 3.4 An Arabian building, interior view.

3.4.2 Efficient methods of collecting light

The purpose of a light admitting element must be: (i) to provide comfortable and adequate light for most of daylight hours, (ii) to lose no more heat by conduction during an extremely cold day than is received as light on a design minimum overcast day (100 lumens of light carries 1 W of heat), (iii) to admit no more heat and light on a hot sunny day than the building can absorb without overheating. It is difficult to satisfy all three of these aims in one building. In cold climates the third can be satisfied but not the first, and vice versa in warm places.

Direct sunlight provides light at about 100000 lux directed from the Sun. The sky provides diffused light from the whole hemisphere, mostly from overhead. The amount of light varies from about 25000 lux from a thin layer of hazy cloud, through 10000 lux for a clear blue sky, to 5000 lux on a heavily overcast day. A vertical window receives light from less than half of the sky. It may get reflected light from the ground or it may be shielded by neighbouring obstructions. A horizontal roof light gets 2.5 times as much light from the sky as a vertical window.

The available light in cloudy maritime climates is predominantly diffused from the overcast sky and comparitively little energy is provided by direct sunlight, which predominates in continental and desert climates.

Figure 3.5 A weaver's cottage (from Hoskins, 1955).

The EC work (Fig. 3.1) was for six zones of Europe, taking into account climate, latitude, orientation, and single or double glazing. Improvements in window design will change the shape of the graphs. Windows which face the closest geographical pole, i.e. north facing in the Northern Hemisphere and south facing in the Southern Hemisphere, receive as much light from an overcast sky as windows facing the Sun. The variation in illumination due to north- and south-facing windows in the appropriate hemisphere is small and tolerable. However, it is not possible to light all rooms in this way. Windows facing the Equator, on the roof, and facing east and west tend to receive too much light from the Sun if they are large enough to collect enough light from an overcast sky.

Windows

The best a window can do is transmit all the light which falls on it. The light transmittance of camera lenses is improved by a few percent by adding an interference film to prevent reflections. Reflecting films and tints reduce the light transmittance. Horizontal roof lights receive light from all parts of the sky, so for a 10% daylight factor they have to be just over 10% of the roof. Windows have to be well over 2.5 times as big.

The efficiency of windows as light gatherers falls off when their other properties are improved. Double glazing and low emissivity coatings reduce the light transmittance. Shades to restrict direct sunlight have a disastrous effect on light transfer from overcast skies unless they are moved away from the window when the light level is low.

Windows which face away from the Sun are subject to light levels between 5000 and 25000 lux and are protected from the 100000 lux of direct sunlight. Where high light levels are needed for Victorian studios, north lights provided fairly uniform light without overheating. Direct sunlight from an overhead transparent roof light causes intolerable overheating. The roof light should be made of a diffusing material. Windows need some sort of moveable blind.

Optical fibres and mirrors

The Sun's light comes as parallel rays. For climates where the Sun is reasonably reliable a focusing mirror can track the Sun, focus it and transmit it down an optical fibre (Fig. 3.6). The ends of the optical fibre can be task lights. A mirror of area $1m^2$ can collect 100000 lumens, which then has to be spread out over say $1000m^2$ of building to provide 100 lux. A focusing mirror tracking the Sun has already been made and optical fibres are already used for transmitting light from an intense artificial source to individual locations.

Light tubes

Diffuse light from the sky cannot be concentrated, i.e. it cannot be focused. If diffused light is to be piped around a building in light guides, i.e. tubes with mirrored walls, then the light must be concentrated. If the overcast sky provides 5000 lux at the roof of a building, and all the light could be concentrated together to be sent down a light guide at 100000 lux, then the light

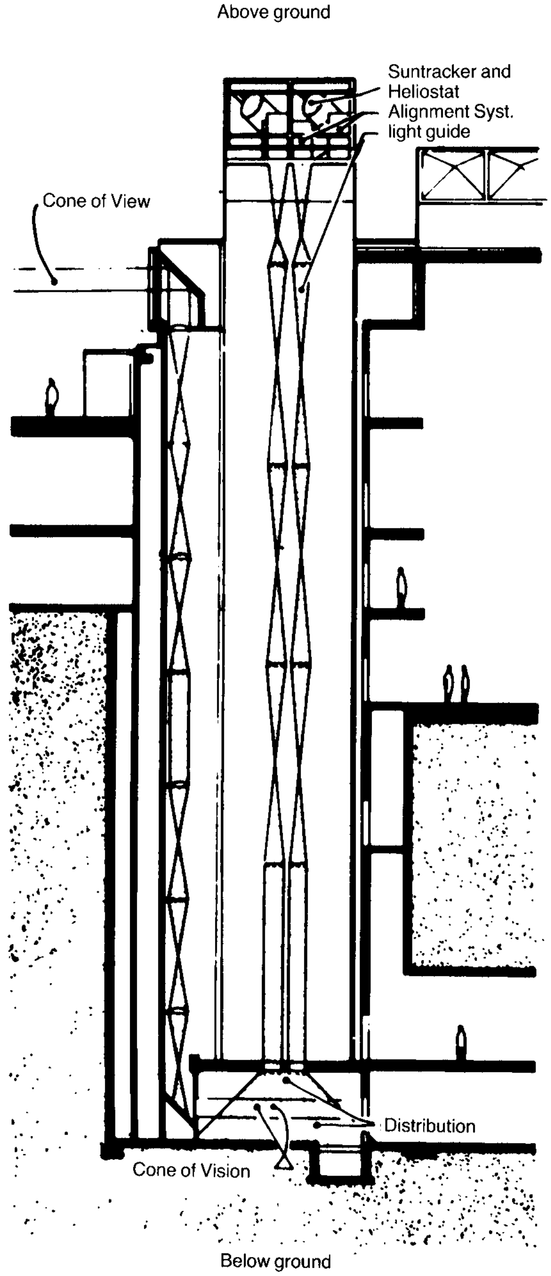

Figure 3.6 Optical fibre and mirror system (from Lechner, 1991).

guide would need an area of 1/20th of the roof area and there would be enough light travelling down it to serve 50 storeys of building at 100 lux or five storeys of building at 1000 lux. Light tubes of this kind have been built but it is difficult to envisage how the light can be collected and redistributed. When the light cannot be concentrated the light distributing tubes are very large and become light wells or atria. I know of some schemes for housing built around an atrium.

3.4.3
Reduction of heat loss through windows

The target for a window should be to lose no more heat than any other element of the building. When windows are admitting light then they are also admitting heat. A vertical window on an overcast day letting in 2000 lumens m^{-2} also allows in 20Wm $^{-2}$, which will sustain a temperature difference of 20°C if the thermal conductivity is 1 compared with the *U* value of 6 for single glazing or 0.6 for quadruple glazing with low emissivity coating. There is never a problem in getting rid of unwanted

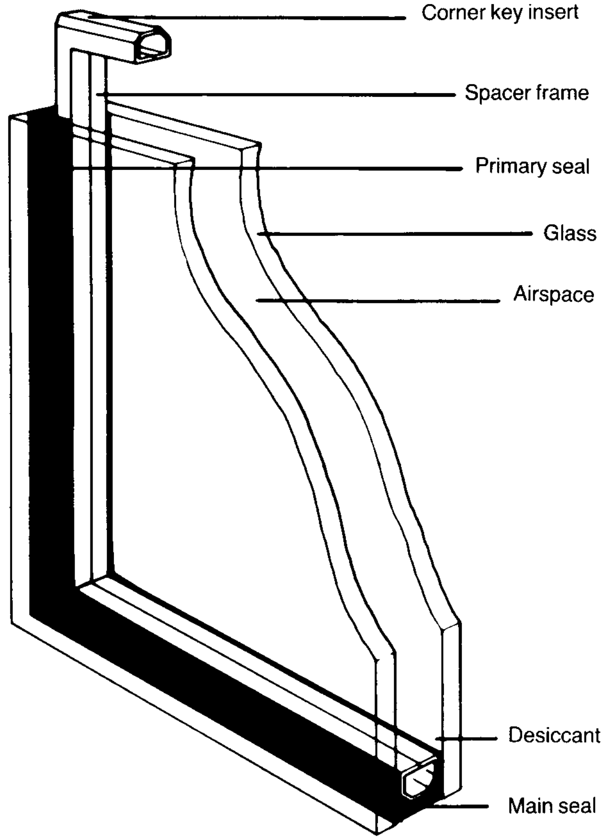

Figure 3.7 Single and double glazing (from Pilkington, 1980).

heat in a space during cold weather. There are various methods of reducing the heat loss through windows. The problem is that they are expensive and as they reduce the light transmission the optimum area increases.

Several layers

Several layers of glass with gas between the layers reduces the heat transmission. Heat is transmitted across the cavity by long-wave (blackbody) radiation at the glass temperature. Internally silvered glass also cuts off the flow of light and is not useful. Coatings with low emissivity to long-wave radiation and which are nearly transparent to light are applied.

Single and double glazing (Fig. 3.7) are included in the EC's charts for energy use (*Working in the city,* Architectural Ideas Competition). Triple glazing with low emissivity coatings can lead to overheating of the middle pane so that the seal around the edge is broken and the glass itself cracks.

If there are obstructions outside the window which cast sharp shadows on the glass, the thermal stress can lead to fractures of the glass. Toughened glass is a solution to these stress problems. Surely all these problems will be solved in the next few decades.

The gas between the layers of glass has a conductivity which depends primarily on the boundary layers at the glass surfaces, so the conductivity does not depend much on the thickness between the layers of glass. A low specific heat, and therefore an inert gas, does have a lower boundary layer conductivity and can be used.

Quadruple glazing with low emissivity coatings meets the heat loss target for an external temperature of about −8°C, which satisfies most temperature climate conditions.

Thermos

The possiblity of evacuating the space between the layers of glass, as is done in a thermos flask, has not been applied to buildings because of the difficulty of producing a strong enough structure to resist atmospheric pressure. A thermos flask works by having an evacuated high vacuum cavity so that virtually no heat is transferred by convection. The surfaces should have a very low emissivity film. The likelihood that evacuated double glazing will be developed should not be ignored.

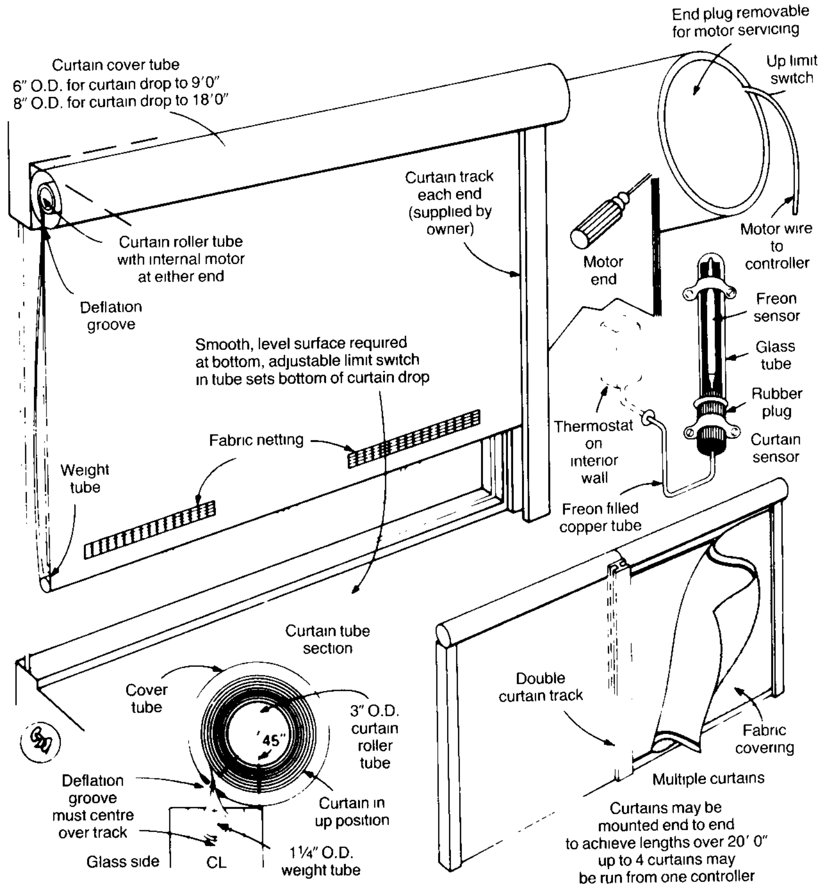

Figure 3.8 Quilted aluminized curtains (from Littler and Thomas, 1984).

Curtains, shutters, blinds, etc.

When it is dark outside and windows are not admitting light then they need to be insulated. The traditional solution to this problem has been curtains and shutters. Insulating shutters need a good air seal around them. This could easily be developed if there were a demand. Similarly, quilted aluminized curtains could be developed (Fig. 3.8). The difference between curtains and shutters is hardly important. The idea of blowing insulating beads between two layers of glass has also been tried in the United States.

All of these solutions need to be developed. They should also be controlled automatically so that whenever the light flow through the window is small or not needed, then the insulating system is automatically brought into play. In general there needs to be means of making windows perform as well as walls when there is no light. The shutters would need to be 500 mm thick.

3.4.4
Reduction in heat gain from windows

Once a solution to providing an adequate quantity of natural light without wasting heat to the cold environment has been found, the next problem to be addressed is that of controlling the amount of light and heat admitted to the room when the Sun is shining directly onto the window. Direct sunlight provides 1000Wm^{-2} of heat and where windows are designed to provide a generous level of natural light, even with an overcast sky, it is important to prevent buildings overheating. If the windows have been sized to optimize the energy consumption the calculations are nullified if the light transmission is reduced by tinting or partial reflection.

When the design light level is reasonably low and the climate fairly cool, means for providing ventilation, especially at night, are likely to be successful. This almost amounts to a restrictive definition of a temperature climate. The storey height of the building should be raised so that excess heat in the air circulates to the top of the building above the zone occupied by people. The excess heat can be removed at night when the outside temperature drops. It can be vented off by a small quantity of air with a big temperature difference between inlet and outlet which can carry away large quantities of heat.

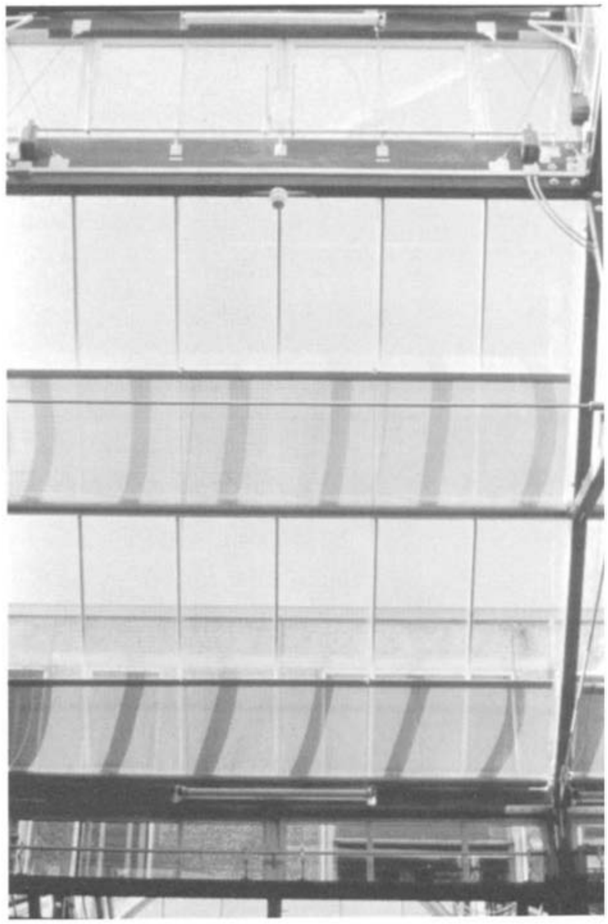

Figure 3.9 St Pauls School atrium.

For most climates or high light levels the windows need shading to deal with bright sunlight. Fixed shades which exclude all direct sunlight also drastically reduce the light received from the overcast sky. Movable shades are needed. Heat intercepted by shades on the outside of buildings is removed by convection currents to the air outside. Shades on the inside intercept the heat, which is then mostly convected back to the inside. Where the heat is conducted back to the occupied zone of a building, it contributes to the overheating of the building. Internal blinds at high level in a building, for instance below a roof light, transfer the heat to the upper parts of the building. If the ventilation is suitably arranged, then that heat can be taken away by ventilation air from the top of the space.

Where the light admitting parts of a wall are glass and where the heat insulation is provided by more than one sheet, then the two sheets can be quite far apart. The space between the sheets will heat up when the Sun shines and it will act as a buffer at an intermediate condition between inside and outside. During the winter it acts more or less as double glazing; during the summer, heat admitted into the space can be absorbed by the walls of the building envelope and re-emitted at night.

Louvres and blinds: moveable or fixed?

In the cooler parts of the temperate zone, where windows are designed for fairly low light levels, overheating during the summer can be corrected by a combination of ventilation and internal blinds, venetian blinds or roller blinds. Reflective blinds and white blinds are more useful than black blinds at at reflecting heat as light to the outside before it is converted into heat.

Because internal blinds are protected from the weather they are less of a maintenance problem than moveable blinds and shades on the outside. However, where the areas of glass are large, external controllable blinds are essential. The inevitable maintenance problems have been tolerated, even during the 19th century. Colonial tropical architecture used alousies. If blinds are to be used externally they need to be robust. Robust louvres are possible.

There are no completely satisfactory solutions to this problem. External a wnings and blinds are thought to need too much maintenance, especially if they are controlled automatically. St Pauls School atrium (Fig. 3.9) and the Museum of Mankind in

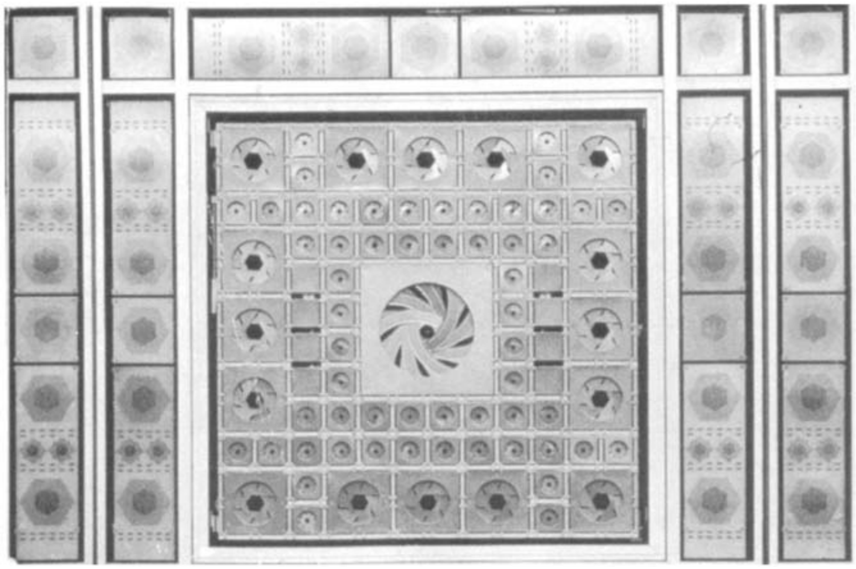

Figure 3.10 Museum of Mankind, Paris.

Paris (Fig. 3.10) are two buildings in which different approaches to automatically controlled moveable internal blinds have been adopted.

There is a perception of the difficulties of maintenance of blinds and lo louvres in front of windows which contrasts strangely with the current acceptance of electrically operated windows in motor cars, where manual operation appears to have been abandoned in favour of the increased maintenance of electric motors to open and close the windows. It would be nice to anticipate that some of the design attitudes which are accepted for motor vehicles will be applied to buildings. Windows with glass to rubber seals and blinds which operate automatically will surely be developed in the next century or so.

Liquid crystal

The idea of the liquid crystal, which can be made transparent or opaque by the application of an electrostatic field, is already under development for large sheets of glass, and is a spin-off of the computer display screen. We can expect the windows to be shaded with computer-controlled colour patterns.

Kerr cell

The idea of the Kerr cell may develop, in which two containers of benzene are made to act as a light switch by applying an electrostatic field across the benzene.

Photochromic glass

Photochromic glass, which is effectively a silver halide photographic film with silver particles suspended in a super-cooled liquid glass, does darken in bright sunlight and acts as an automatic shade. The glass is very expensive and is only used for expensive sun shades. The silver constitutes about one-third of the glass content.

Phase change cell

A cell has been developed which consists of a solution of a salt whose solubility reduces with a rise in temperature. The solution is held in a container, which is the window. As direct sunlight falls on the solution the temperature rises and the salt begins to precipitate. The solution is then more absorbent to the light and the temperature rises rapidly, causing a fairly complete precipitation which obscures the light (Falikoff, 1984). A fairly simple extension of this idea is to provide electric heating to the solution so that the light transmission can be turned on or off at will.

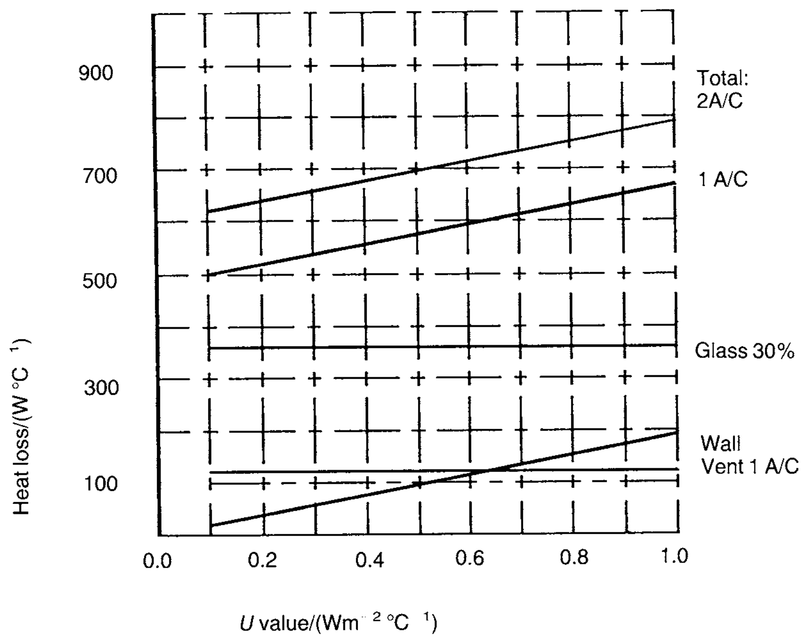

Figure 3.11 Heat loss against *U* value (Fordham, 1991).

Windows for ventilation

It is part of our culture to expect to open windows to provide ventilation. There are good pragmatic reasons to hinge the frame holding lightweight glass. The window with its motorized blinds is still likely to represent the thermally weak chink in a wall. As a complicated mechanism it may remain as the element which can open to enable the building to reject heat by ventilation. A requirement for the window is that it should be part of the mechanical control sy stem. Part of the aim of the envelope of a building for the third millennium is that it should be self-adaptive, adjusting itself according to the outside conditions so as to maintain comfort for the occupants inside.

3.5 VENTILATION

Ventilation is necessary for two reasons: (1) pollutants, water vapour and other smelly chemicals have to be diluted and (2) excess heat has to be removed. The difference between the two requirements is an order of magnitude or so and it is not common to find one design solution solving both problems. Usually, infiltration through almost closed windows solves the first, while wide open windows solve the second.

3.5.1 Low rates

The basic ventilation for removing pollutants is one of the main sources of heat loss in cold weather. At one or two air changes per hour it removes much more heat than is lost through walls insulated to 1991 standards. Fig. 3.11 shows what a small difference insulation makes to walls compared with ventilation.

The heat loss through the wall of an archetypal house, a 7m cube with two storeys, is shown in Fig. 3.11 for various *U* values of the wall. The heat loss through the wall and roof on their own is shown on the bottom line as a function of *U* value. Then the heat loss due to ventilation on its own at one air change per hour and the heat loss due to single glazing are shown. The heat lost through glazing is about 360W; the heat loss from one air change per hour is about 1000W. The resulting total heat loss for different discharge rates is plotted against *U* value. The irrelevance of *U* value seems apparent.

This loss of energy through ventilation cannot be controlled because under quite common circumstances condensation is an intractable problem. The envelope of a building is usually porous enough to provide adequate winter ventilation. Partly as a result of improvements in construction, some houses are being fitted with mechanical ventilation (fans) to the kitchen and bathroom, the rooms where most moisture is produced.

Mechanical ventilation with heat reclamation will enable good ventilation rates to be achieved while minimizing the attendant heat loss. The ventilation should be at one or two air changes per hour supplied to the living rooms and bedrooms

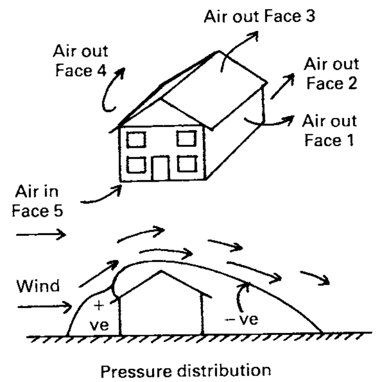

Figure 3.12 Naturally ventilated office.

and extracted from the kitchen and bathroom. Ducts would need to be about 100mm in diameter to each room. The fan and heat exchanger would be about the current size of a boiler. With mechanical ventilation the natural infiltration must be reduced by a factor of 10 below what is general now.

There is a proposal for testing the airtightness of buildings by pressurizing the building to 50Pa, equivalent to about $8ms^{-1}$ ($30kmh^{-1}$) wind speed and determining the leakage rate of the building. The mechanical ventilation proposal implies that the leakage rate should not exceed $0.01m^3s^{-1}$ in this test. The implications are considered in §3.6.

Apparently, the performance of the camel's nose is a piece of standard biology. The camel's breathing system is a heat reclamation system operating as the camel breathes in and out. It evolved some time ago and should provide us with a model for heat reclamation. It would save energy if we could devise natural ventilation with heat reclamation.

3.5.2
Condensation and minimum ventilation

Condensation in buildings is an intractable problem and so no energy conservation measures are based on reducing ventilation heat loss, although it must be a prime candidate for attention. The ventilation rate should perhaps not be reduced, but instead we should rely on mechanical ventilation arranged so that the heat being discharged in the outgoing air is recovered and used to heat the air being taken in.

The problem with this proposition is that it is important that all the air flowing into the building goes through the mechanical system during cold weather. Standard buildings now are leaky enough to provide about enough ventilation with all openings more or less permanently closed. Thus the ventilation takes place and no heat is recovered from the ventilated air. If heat recovery is to be useful, the building must be thoroughly sealed. The ventilation rate for a house needs to be about one air change per hour. This is a crude measure and I would design a mechanical system for two air changes per hour. To save heat then we need a building which has negligible openings in it for natural ventilation. The design target should be 0.1 air changes per hour by natural infiltration. Consider the archetypal house. It is 7m wide on two floors, say 7m high and it is 7m deep, and has about $100m^2$ of floor area. The volume is about $360m^3$. The principles are shown in Fig. 3.12.

One air change per hour is equivalent to $0.1m^3s^{-1}$. The design natural ventilation rate should be achieved during a reasonably windy day, i.e. a wind speed of $10ms^{-1}$ ($36kmh^{-1}$). A house has five faces, one of which is exposed on the windward side and the other four of which are in general to leeward. The pressure difference between the outside of the leeward face and the outside of the windward face is roughly one wind velocity pressure. If the cracks in the building envelope are uniformly distributed about the faces, then air comes in through one face and goes out through the other four. The volume of air is conserved so the velocity of the air in the outgoing cracks is one quarter of the velocity in the incoming crack. The pressure differences are in the ratio of 16 to 1. This means that roughly speaking one wind velocity pressure is applied to the cracks in the windward face of the building. Then the equivalent orifice area of the cracks is given by speed through the orifice of $10ms^{-1}$. The windward elevation has to have a crack of area of $0.001m^2$. This is 1m×1mm. The $10ms^{-1}$ wind speed represents the stagnation pressure of 60Pa. With this pressure across the elevation we equivalent faces, then we could test the ventilation resistance of the building expect an airflow rate of $0.01m^3s^{-1}$ or 10 ls^{-1}. If the building has five by putting a fan in the door with a duty of 50 ls^{-1} at 50 Pa to ensure the building was properly airtight. We would find the set of requirements very difficult to achieve. Refrigeration cold stores are constructed so as to minimize the heat load. The doors have very heavy hinges thoroughly rebated with extruded neoprene seals and very heavy clamps.

3.5.3
Summer ventilation

During the summer, buildings tend to get too hot. The average daylight factor of a window is likely to be about 4% in a room, which implies a lighting heat gain of around $40Wm^{-2}$ from direct sunlight. In a temperate climate the outside air temperature at midday is likely to be uncomfortably hot and the temperature inside will not be reduced. The strategy to prevent overheating has to be that the building responds to the average outdoor temperature and it is ventilated as much as necessary at night to cool it down to the lower limit of comfort. Heat is then injected into the building during the day from people and their activities but mostly from natural light. This heat, which is liberated during the day, raises the temperature of some of the air. The warm air rises to the upper parts of all the rooms and heat is absorbed into the ceiling and into the upper parts of the walls. Whenever the outside air is cool enough heated air can be let out of the building and replaced by comparatively cool outside air at low level in the building.

In cool parts of the temperate zone the ventilation procedure on its own may be enough to prevent overheating but in general it is important that the building is tall enough and heavy enough to absorb heat so that it is not necessary to rely on ventilation during the day. For the United Kingdom the design condition is a day of maximum solar insolation when the peak outside air temperature is 25°C, the mean is 19°C and the minimum around 13°C. Buildings with walls and ceilings which cannot absorb heat and with closed windows do get very hot. For example, anybody who has a Victorian house with a Mansard roof and has gone away for the weekend in hot weather, leaving the windows closed for security, must know how hot such a space can get. Admittance of the walls and ceiling has to be kept high (see §3.6). The floor to ceiling height should be generous.

Summer ventilation needs to be in the range 10–100 air changes per hour and needs very large openings compared with the winter. Ventilation at night and when the building is unoccupied must be arranged so that rain, strong wind, and people are excluded.

Ventilation can be driven by the wind. Usually one wall at least is subject to wind pressure and the roof will be at a negative pressure. If wind speed is less than $1ms^{-1}$, the stack effect (thermal syphon) can drive the ventilation. Chimneys from open fires drive natural ventilation fairly efficiently.

Housing in cool temperate climates with moderate design light levels does not overheat if the walls are lined with reasonably dense internal surfaces and there are reasonable ventilation openings. To extend the temperate zone philosophy towards the tropics attention has to be paid to good night-time summer ventilation and mass in walls for absorbing heat during the daytime. Summer ventilation openings should be linked into the heating system so that the heating is switched off if the vents are opened.

We need ventilation at both low and high level. The design wind speed is say $1ms^{-1}$, and ventilation rates of the order of 20 air changes per hour are common. The windows need to be able to be left open at night and during weekends when the house is unoccupied. The continuous nighttime ventilation has to be protected against excessive wind speed, rain coming in, and people intruding. In my view a vertical sliding sash window solves nearly all these problems but it is not very modern and it is not very easy to seal.

3.6
CLADDING

The flow of energy through cladding is complicated and can be considered under various headings. The CIBSE Guide deals with the matter in Section A3 (CIBSE, 1990). A building with very thick walls and no windows, or people needing ventilation such as in a pyramid in Egypt, would remain at a stable temperature very close to the mean annual temperature. In Egypt this is about 20°C. Heat produced inside the building flows through the walls. The amount flowing out responds to the mean temperature difference and the thermal conductance of the wall (*U* value).

As the temperature difference between inside and outside varies about the mean so the flow of heat varies about the mean. The amplitude of the variation depends on the *U* value and a function called the decrement factor (which is related to the thickness and thermal mass of the wall), combined with the length of time of the fluctuation. As the temperature in a room fluctuates about the mean inside temperature so heat flows into the surfaces facing into the room. Over the period of a fluctuation the overall flows of heat into the surface cancel out the flows out of the surface. The peak rate of flow is related to the extreme fluctuation of temperature by a property of the surfaces facing the room called the admittance.

The overall heat loss from a building needs to be balanced against the overall heat production by adjusting the *U* value and the decrement factor. Fluctuations in temperature produced by fluctuations of heat production in the building have to be damped out by adjusting the area of the internal surfaces and their thermal weight (admittance).

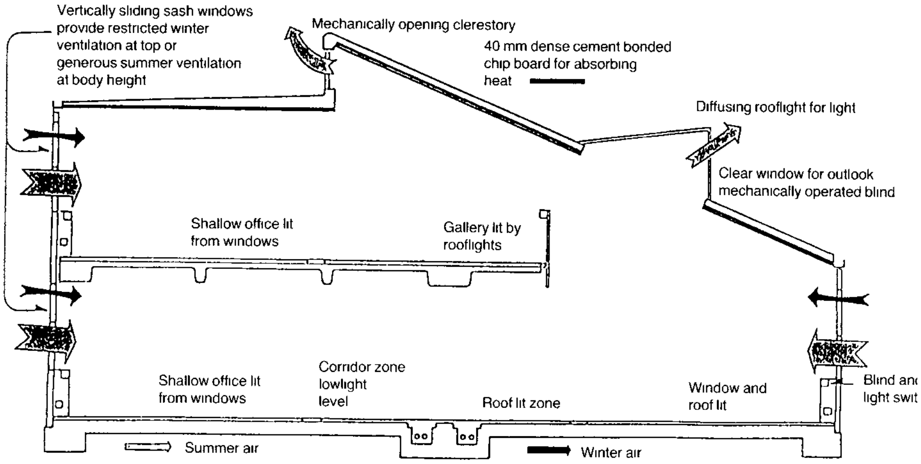

Figure 3.13 Section through naturally ventilated office building.

3.6.1 Internal oscillations: admittance

It is rare for the internal temperature of a building to remain constant. Sometimes a process requires that a constant temperature be maintained, but usually some variation is expected. If a constant temperature is to be maintained a building is likely to need cooling at midday and heating at night. It is the common experience of most of us in the UK that from April to September we live in buildings which need neither heating nor cooling. The temperature of a house may vary from say 18°C in the morning to 25 or 27°C in the evening. We accept this range of temperatures (Building Research Establishment, 1966).

While designing buildings our practice often carries out calculations to ensure that a building is likely to remain comfortably cool during the summer. The calculations involve the likely heat release from occupants, ventilation air, and natural light balanced against the areas and admittances of the internal surfaces. For houses in the UK overheating is not a problem unless there is too much natural light, the surfaces are too light, or there is too little ventilation, especially at night. We have carried out these calculations for a university in the temperate climate of Doha, which was air conditioned.

To prevent overheating in a naturally ventilated office we suggested that the internal surfaces should be lined with 40 mm of dense cement-bonded chipboard (Fig. 3.13).

Hot climates, with a wide diurnal range of temperatures and with summer nighttime temperature well below the optimum for summer comfort, can be considered as temperate. Careful control of daytime heat release— restricting daytime ventilation, covering windows when rooms are not in use combined with tall, heavy walls and ceilings—allows heat to be stored during the day and released to the outside by generous nighttime ventilation. A traditional Mediterranean building works in this way.

Table 3.1

Period	*Wavelength*	*Phase change*	*Half wavelength Decrement 0.04 Thickness*	*Phase change*	*0.36 Wavelength Decrement 0.1 Thickness*
1 day	0.9m	12 hours	0.45m	9 hours	0.3m
1 month	2.6m	15 days	1.3m	1 1 days	0.9m
1 year	16m	180 days	8m	130 days	6m

Thermal capacity (admittance) is increased by providing ventilation through extended surfaces such as hollow concrete beams. The oscillation into and out of the surfaces is measured by the admittance. A space with a large area of dense conducting wall linings heats up only slowly during the day while one constructed of 10 mm plasterboard with a lightweight insulating false ceiling heats up quickly.

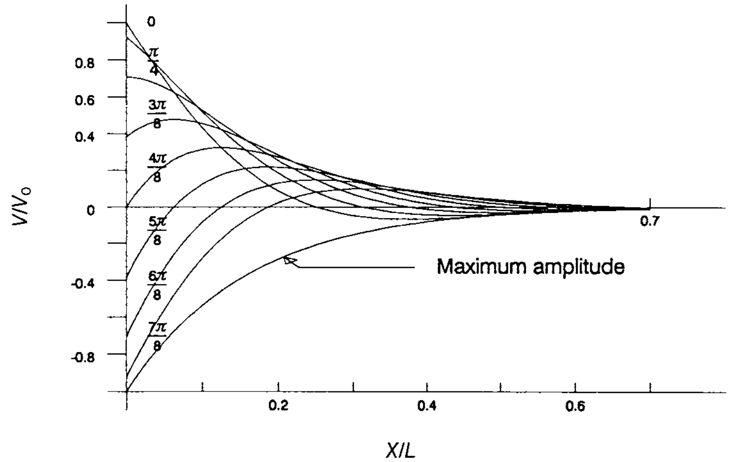

Figure 3.14 Temperatures in a wall at times repressed by 0 to π, where $V/V_0 = \exp(-2\pi x/l)\cos(wt - 2\pi x/L)$ $L=2\pi\sqrt{(2k/w)}$ is the wavelength of the thermal disturbance, *w* is the angular frequency, $k=7\times10^{-7}$ is the diffusivity of masonry. (Fordham, 1981.)

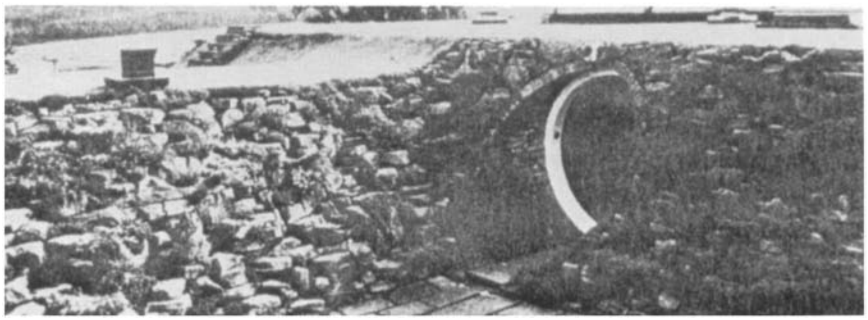

Figure 3.15 Arthur Quarmby's underground house, Holme, West Yorkshire (from *Country Life,* 30 October 1986).

3.6.2 Heat flow between inside and outside

A building designed to optimize heat flow due to lighting and ventilation will need to minimize heat exchange to the outside through walls, roof and floor. During hot weather surplus heat has to be removed to the outside by ventilation and during cold weather any surplus heat can easily be removed in the same way.

A wall can do better than provide isolation from extremes of temperature, it can reverse them. A wall of the correct thickness can cool a space down during the summer and heat it during the winter. The effect is very small. Consider a pyramid in Egypt. The annual mean daily range of temperature in Egypt is ±10°C. A wall 8 m thick would provide maximum cooling in the summer equivalent to a temperature different of 0.4°C. A thinner wall provides isolation from 90% of the fluctuation (Fig. 3.14, Table 3.1).

The practical way to make a building respond to the annual mean temperature is to bury it in the ground or call it a cave. Light then has to be admitted down tubes. Arthur Quarmby has built an underground house in the Pennines in Yorkshire (Fig. 3.15). If the mean temperature is too cold for comfort then the cladding has to be insulated.

The fluctuating external temperature of the cladding depends on air temperature, on radiation to the night sky and on light radiation. A flat roof receives 50Wm^{-2} and a wall 20Wm^{-2} by day from an overcast sky. Fig. 3.16 shows a wall clad with a transparent insulating material. The light is absorbed at the wall surface where the heat is inhibited from being conducted to the outside. In this way the mean temperature at the outside of the wall is raised and the mean heat outflow is reduced.

Three people give off 300W. They are not in the house all the time but they will be using some electricity for lighting at night. Even when household equipment has been improved it will give off heat. The cladding of a house of an area 300m^2, i.e. six faces to a 7m cube should have a target to lose 300W during cold weather, in the UK this implies a *U* value of 0.05Wm^{-2}.

In theory this *U* value will need a good foam plastic insulation of thickness about 500mm. There is a real problem in achieving very low *U* values. Air flows through and round the insulation with cold bridging, making a nonsense of the calculations. Common problems are indicated by Fig. 3.17. Note that the insulation has gaps between it so air can circulate. This negates the purpose of the insulation.

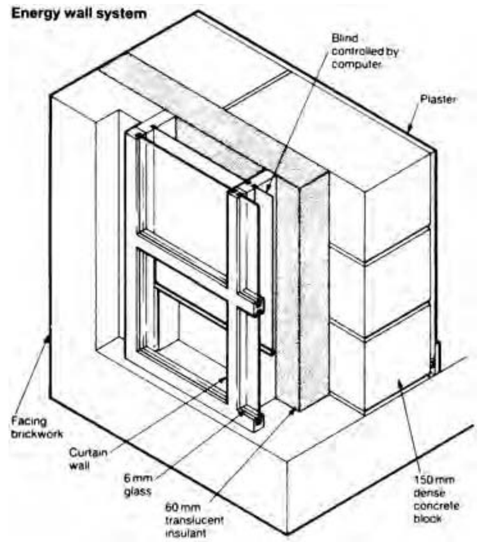

Figure 3.16 Energy wall system (from Living Daylights, *Building,* 18 August 1989).

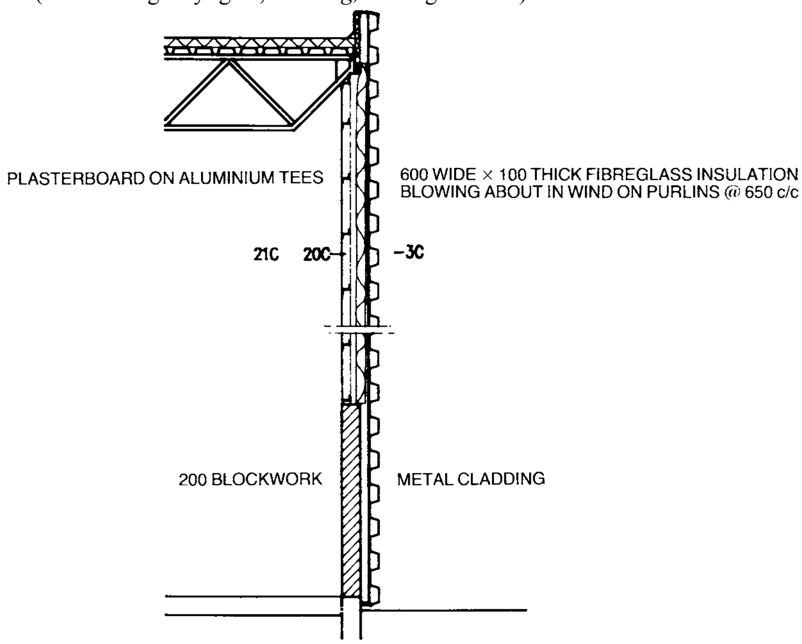

Figure 3.17 Common problems in achieving low *U* values.

3.6.3
High *U* values exacerbate moisture movement problem in walls

Measures to control moisture movement combine with measures to control ventilation, and the cladding of a building will need to incorporate a thoroughly sealed lining. Many of these problems have been encountered and solved in the construction of cold stores. Modern closed-cell foamed plastic without CFCs is enclosed within a sheet metal sandwich. Old cold stores used two sets of stud set at 90° to one another. The insulation was placed in two layers, each embedded in hot bitumen.

Of course insulation materials will be improved. Low density fibrous and cellular insulation inhibits heat flow by convection, leaving heat transfer by radiation across the spaces to predominate. Silvered fibres would improve the insulation. Possibly the foaming agent could incorporate something like Fehlings solution, which would leave silvered surfaces in plastic insulation. Crumpled metallized plastic and foil are also on the horizon.

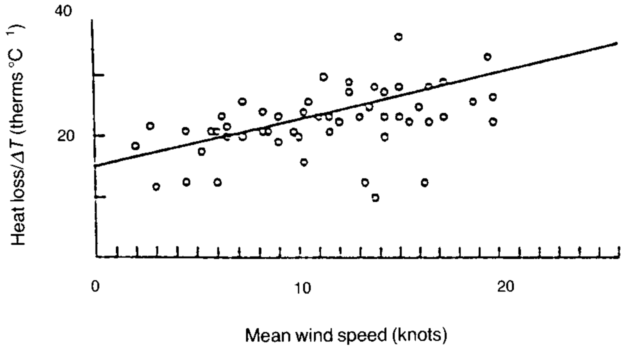

Figure 3.18 Heat loss against mean wind speed (Fordham, 1991).

3.6.4
Moisture

Condensation and moisture problems are intractable in British housing. We do not understand the issue well enough to give occupants advice on how to combat these problems. The theory of flow using the parameters of resistance, admittance and decrement factor should be developed in the next few years to enable designers to deal with unsteady-state moisture problems.

3.6.5
Air flow

The permeability of cladding to air flow is currently a severe problem. The air flow tests referred to in §3.5.2 above will be part of solving the problem. Fig. 3.18 shows a plot of heat loss with wind speed added as a variable. The heat loss at zero wind speed was many times the calculated heat loss. The slope represents the heat loss and so ventilation rate for different wind speeds. Again the building was not behaving as predicted by the design calculation. The solution to this problem was to seal the leaks in the envelope.

3.7
COMPUTER CONTROLS

A central part of controlling light levels and temperatures is that the control is continuous, whether people are in or out. Automatic control of window openings, blinds and louvres is already being provided. This will develop and become part of the computerized building which will react to variations in the weather.

3.8
CONCLUSION

The money system is not capable of initiating the necessary changes. Wars are not initiated by market forces and the war against carbon dioxide pollution and fuel depletion requires that resources be deployed to develop the necessary weapons. That weapons are developed and stockpiled before their use is imperative.

We need to be developing the following building components: (1) light admitting elements with integral control of insulation and transmittance; (2) heat reclamation ventilation systems with very high levels of performance and with the self-cleaning properties of animal lungs; (3) insulating materials and methods of fabrication for cladding. The research effort should be comparable with the trip to the moon. The ends are more worthwhile.

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4
Design considerations for exterior envelopes of buildings in cold climate regions beyond 2000

L.T.Hendricks and P.H.Huelman

4.1
INTRODUCTION

For some, the term 'cold climate' is used to describe geographic regions of the Earth where snow remains on the ground for at least some portion of the year. For others, the term refers to the 'north', which has been described as the area located north of the southern limit of scattered discontinuous permafrost (Fig. 4.1) (Larsson, 1985).

Buildings in cold climate regions of the world have traditionally been plagued with severe moisture problems and premature deterioration of the building structure. As efforts were made to 'tighten' buildings to make them more energy efficient, new problems began to develop; specifically, indoor air quality became an issue. In addition, the deterioration of the building envelope accelerated, and some dwellings experienced severe decay problems within 5–7 years of their completion. A few innovative builders began to recognize and deal with these issues of cold climate construction. Phrases such as 'build tight and ventilate right', 'drying potential of the envelope', and the 'house is a system' began to surface (Fig. 4.2). The key features of a cold climate house are as follows: carefully installed installation; continuous air barrier; warm-side vapour retarder; weather barrier; condensation-resistant windows and doors; control of ground moisture and radon; controlled (whole house) ventilation; safe and efficient combustion systems.

There are several challenges in building structures for cold climate regions of the world. Above all, they must be energy efficient, safe for the occupants, comfortable, economical, and constructed in a manner that prevents premature deterioration of the building envelope. In the decades ahead, two emerging issues will dominate the residential construction industry. They include performance standards for the envelope and solving the question of excessive pressure differentials across the envelope.

4.2
PERFORMANCE STANDARDS FOR THE STRUCTURE

4.2.1
Introduction: an analogy

A critical need in residential design and construction today is an appreciation and understanding of house performance. Home buyers are investing a very large portion of their income for housing and have very little information on how it will perform. Important performance issues today should include energy consumption, durability, indoor air quality, and safety.

It is instructive to compare and contrast the purchase of a car and a house (Table 4.1). Car buyers will generally evaluate their transportation needs and select a type of vehicle that will meet those needs and begin to narrow their choices to styles which meet their aesthetic taste. They will use performance indicators such as miles per gallon, maintenance reports, and

Table 4.1 Contrasting buying processes

	Car	*Home*	*Decision basis*
Type	Ford	2 Storey	Function
Style	4 Door	Tudor	Aesthetic
Performance	V8	?	
Accessories	Air cond., etc.	2 Baths, etc.	Features

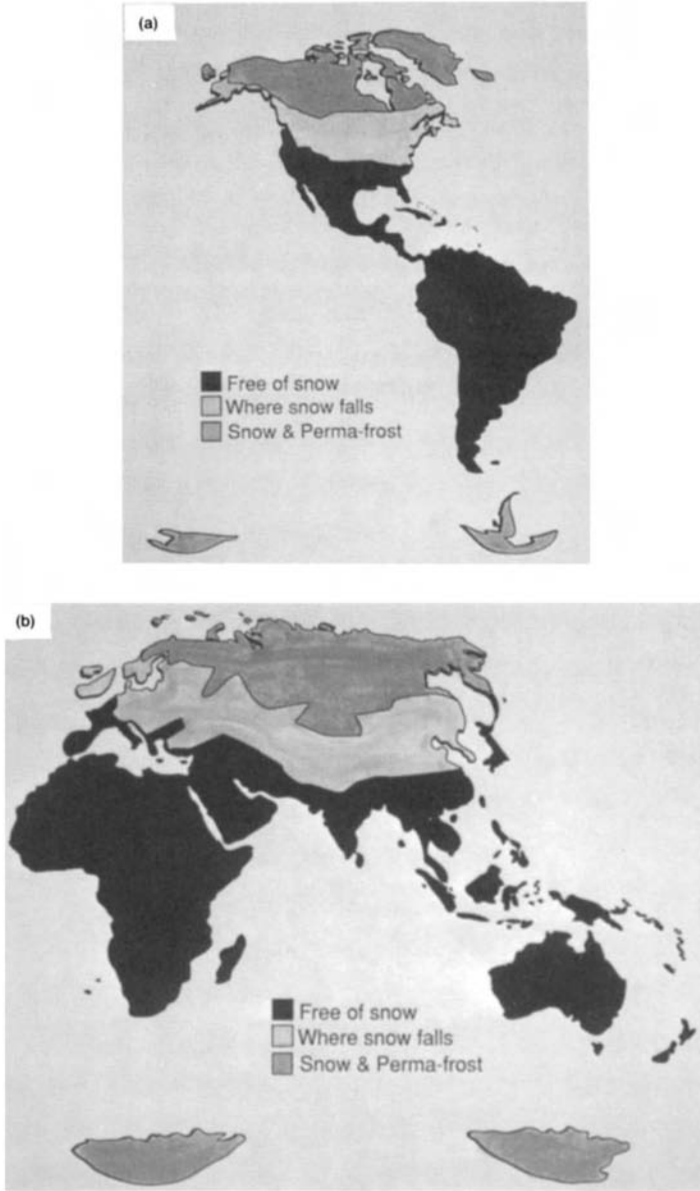

Figure 4.1 Permafrost and snow regions of (a) the Western Hemisphere, and (b) the Eastern Hemisphere.

consultation with owners of similar vehicles to make a specific model selection. Finally, decisions are made regarding optional equipment.

On the other hand, a home buyer will typically make an early decision on the general structure, including type (e.g. two-storey, split-level) and style (e.g. traditional, contemporary). Then the home buyer proceeds to select specific features (e.g. vaulted ceilings, spas and whirlpool tubs, windows, kitchen appliances, heating and cooling systems). While some discussion of individual component performance might take place at this time, rarely is there any attempt to ascertain how the house will perform as a system.

This clearly highlights a need for performance-based measures and standards. A performance approach is a critical step for two reasons. Firstly, quantifiable performance measures will allow home buyers to evaluate and compare various houses. Secondly, performance standards will provide the building industry with certain flexibilities in meeting specific performance targets set by buyers or regulating bodies.

With such compelling arguments for performance standards, why are performance standards not prevalent? The answer is that before performance ratings or standards can be developed there must be a clear appreciation and agreement as to which performance issues need to be addressed; and secondly there must be general acceptance of methods that can be used to measure and verify performance.

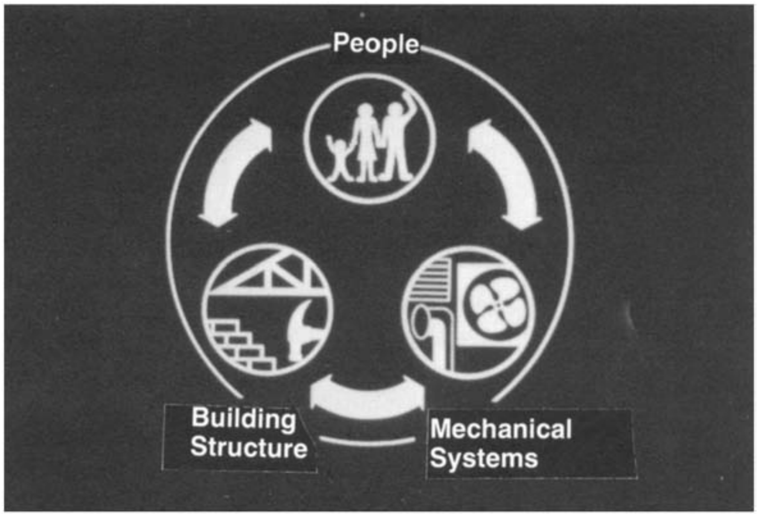

Figure 4.2 The house as a system.

4.2.2 Evolution of performance standards

By definition, performance measures must be integrative and account for the impact of many related factors. This inherently means that performance standards can only be developed once the critical relationships and variables are well understood and easily measured. In that sense, all performance standards logically follow a common development process. The first step is the recognition of important performance-related issues. Next, all major variables must be quantified in a research setting with general consensus reached on the key performance aspects. Then, simple methods to measure performance are developed and consensus is reached regarding the appropriate use of these methods. At last the road has been paved for introduction and subsequent adoption of a performance-based standard. In addition, performance standards are generally additive. This simply means that performance measures will move from simple to complex and from steady state to dynamic applications. For example, in housing the first step is product performance. Then, this can be expanded to component performance and later extended to system performance. Ultimately, these can be further developed into total house performance measures and standards (Table 4.2).

Table 4.2 Evolution of performance standards

4.2.3 Current measures of performance

There are a number of common performance measures or standards in use today. For instance, with cars miles per gallon is readily accepted and used by car buyers as one measure of performance. This same measure has been used as a performance standard by government to ensure that the automobile companies meet a minimum fleet efficiency.

Likewise, there are performance measures or standards for some products and components in homes today. In terms of products, there are insulation requirements and insulation standards dictated by building codes. And there are appliance ratings and, in the US, recently adopted federal appliance standards. There are some component measures as well, such as heating and cooling efficiency ratings.

Currently there is much discussion and development of performance measures for house systems. For instance, there is a great deal of activity in performance measures and standards for the thermal envelope of buildings. One such programme is the ‘Home Heating Index’ and associated ratings developed by Iowa State University Extension (Hodges *et al.,* 1982). The rating has been used for various voluntary programmes for almost 10 years and was incorporated into the Iowa State Building Code in 1987. Another programme which has explored the cutting edge of building thermal performance standards is the R-2000 project in Canada. This resulted in an exemplary standard which was designed to achieve a high realistic level of energy efficiency and indoor air quality for the structure.

A key issue for the efficiency and durability of buildings in cold climates is the airtightness of the building envelope. Upon recognition of this important performance issue, several ways to measure airtightness were developed. The most common approach is to use a blower door. This device, which temporarily fits into an exterior doorway, can pressurize or depressurize the home while measuring the airflow through the attached fan unit. A small airflow at a high pressure difference would indicate a very tight home. Also, this equipment can be used to test for pressure differentials in a home resulting from combustion equipment, exhausting devices, and forced-air systems.

Recent attention to building airtightness and the increase in potential pollutants in our homes has demanded a more comprehensive, performance approach to building ventilation. For residential buildings this field is still in its infancy. However, some jurisdictions are incorporating ventilation standards at the product and component levels. It is likely that system measures and standards, such as ventilation system effectiveness, will follow close behind.

There have been several programmes to improve the energy efficiency of homes in the United States. Many of them have recognized the important related performance issues of combustion equipment safety and indoor air quality and, as a result, these programmes now require a ventilation system. The following is an example:

Heating energy <2.5 BTU ft^{-2} deg^{-1} (5.7Wm^{-2} K^{-1}) Building air tightness <1.5 air changes per hour at 50Pa Mechanical ventilation=0.35 air changes per hour (Combustion equipment must be sealed)

Ultimately we must have total house performance measures. To make energy-wise decisions, a method is needed to compare and evaluate similar products. It would be extremely useful to have a good measure for the total energy performance of homes. This measure should be similar in nature to the miles per gallon for automobiles. Having such a performance measure for homes will help bring energy efficiency into the marketplace. It would allow both new home buyers and existing homeowners to compare the efficiency of various homes, and to determine the benefit of future energy conservation measures. Builders of energy-efficient homes or homeowners who have made significant energy improvements would have a legitimate basis for a higher sale price. In the near future, we should be able to quickly ascertain the total building energy index at the design stage or at the time of purchase.

Another critical performance issue is indoor air quality. At this point in time we can only speculate as to how performance measures and standards might evolve in this important area. First, we must identify the major potential indoor pollutants and then, through comprehensive research, determine the levels at which each pollutant might have serious health effects. Once there is general consensus on allowable pollutant exposures, then reliable monitoring equipment and test procedures must be developed. Once these have proven successful and are readily available, performance standards can be initiated. Someday we should be able to ask for the total building indoor air quality index.

As we improve our understanding of building science and make major advancements in building technologies, we will undoubtedly move towards more sophisticated and comprehensive performance standards. These performance standards must be specifically developed to be appropriate to the region and climate, reasonably accurate and repeatable, applicable to a wide range of conditions and products, allow certain flexibility and innovation, and yet provide ease of implementation. Performance standards will play an important role in future buildings. How much and how fast will depend on the building science community and the consensus process.

4.3
EVIDENCE OF BUILDING FAILURES

Most of us would have little difficulty in identifying examples of building deterioration commonly found in cold climate regions. Perhaps 90% of these problems are associated with or are caused by moisture. The more severe problems are usually located in structures with high pressure differentials across the envelope, and are coupled with the envelope's inability (as a system) to deal with the imbalance.

In the Minneapolis-St Paul region of Minnesota, we annually encounter many examples related to improper cold climate construction techniques. Among them are mould and mildew in closets and at ceiling-exterior-wall interfaces (Fig. 4.3). Paint failures and abnormal dimensional change in wood-based siding materials are common. Improperly placed vapour barriers/retarders are also a problem (Fig. 4.4), but one of the greatest areas of concern is the lack of properly installed air barriers and balanced controlled/managed ventilation systems. (See also Figs 4.5 and 4.6.)

4.4
PRESSURE DIFFERENTIALS ACROSS THE ENVELOPE

The underlying premise behind performance standards for housing is that the structure operates as a system. Houses must not be depressurized or pressurized beyond certain limits; thus house pressure measurements will grow in importance as a means of measuring performance. Issues related to pressure differentials include: spillage and backdraught of combustion appliances, flame roll-out from the bottom of gas water heaters, soil gas entry, and moisture migration through the building assembly (Tooley *et al.,* 1991)

Figure 4.3 Mould and mildew are common occurrences where air circulation is poor and dew points are easily reached.

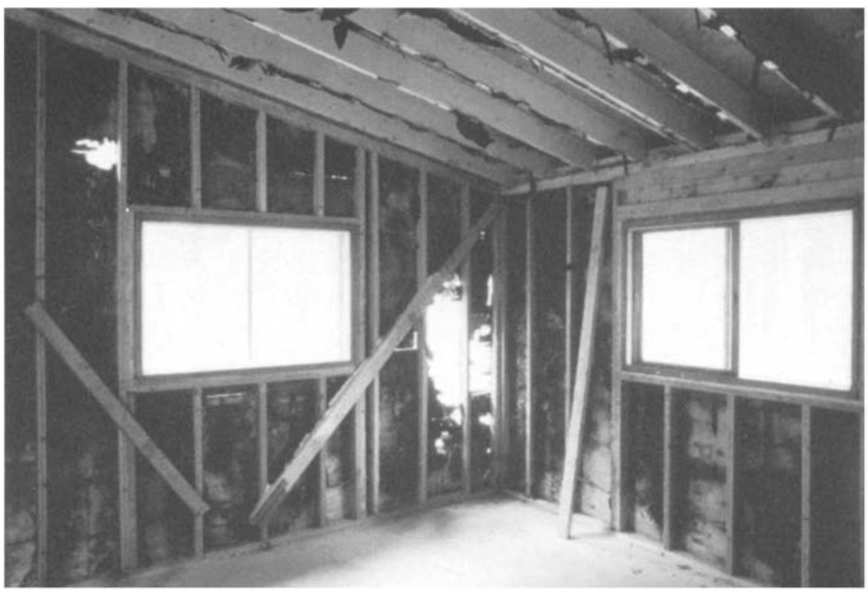

Figure 4.4 Deterioration in the plywood sheathing of an exterior wall caused by an improperly placed vapour retarder and the lack of a continuous air barrier.

4.4.1
Factors associated with pressure differentials

Air pressure differences between various components of the thermal envelope lead to air leakage (infiltration and exfiltration). What creates these pressure differences across the walls or ceilings? First, there is the stack effect. Then we have the effect of wind on the exterior of the envelope. And finally, we have two factors associated with the mechanical systems: (a) combustion appliances and exhaust fans, and (b) forced-air systems. (See Figs 4.7 and 4.8.)

At any given point in time, some or all of these factors which cause pressure differentials in varying degrees may be at work. Buildings located in extreme cold climate regions will have the greatest pressure differentials, and consequently the greatest potential for building degradation and indoor air quality problems.

Figure 4.5 Ice dams are common in many cold climate regions.

Figure 4.6 Sidewall moisture and external discoloration are evident on this cathedral ceiling house that has an inadequate air barrier.

4.4.2
The need for automated integrated control systems

Because building occupants rarely take it upon themselves to monitor or manipulate control systems, the building of the future will require automated systems that sense and correct abnormal pressure differentials as they occur.

In cold climates, pressure differentials greatly impact moisture migration, frequently driving moisture-laden air through building envelopes. Where dew points are reached, mould, mildew or decay can occur and deterioration of the structure may develop within five years or less. Strong continuous positive pressure differentials (greater than 7–10Pa) may be associated with envelope failures in cold climates, while strong continuous depressurization levels, in the range of −4 to −7Pa or greater, may be associated with backdraught, radon entry and diminished indoor air quality. Although wind and stack effect are important sources of pressure differentials, we believe pressure differentials across walls and ceilings (caused by poorly balanced mechanical systems) to be a major factor in building deterioration. This is especially true in tightly constructed houses without good air management systems.

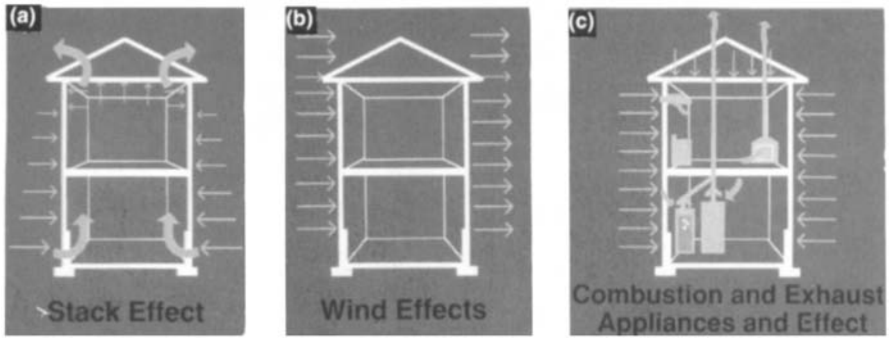

Figure 4.7 Pressure differentials induced by (a) the stack effect, (b) the wind effect, and by (c) combustion and exhaust appliances. Based on CHBA, R-2000 Builder's Manual (CHBA, 1987).

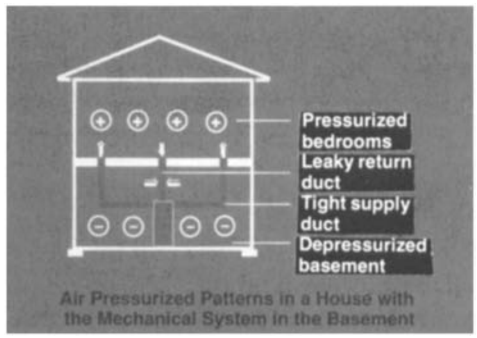

Figure 4.8 Air pressure patterns in a house with the mechanical system in the basement (based on a drawing by Lstiburek (1992)).

4.5
BUILDERS ARE SLOW TO CHANGE

There are devices, controls, materials and methods of construction that can cope with virtually all of the problems we encounter in modern homes being constructed in cold climates regions. However, this technology often goes unused, and application lags the available technology by a decade or more. Builders resist change, often arguing that consumers (homeowners) will not pay for things they cannot readily see. Yet we know that the performance of buildings could be substantially improved if designers and contractors were more careful about construction variables over which they have control. They include placement and selection of insulation and air barrier systems, the reduction of pressure differentials which cause air infiltration and exfil ration, and the proper design, installation and operation of forced-air distribution systems.

We know that many energy-efficient designs are possible for cold climate structures. However, good quality control in all phases of the construction process is essential if we want the structure and design to deliver its maximum potential for energy savings, comfort and occupant safety. Unfortunately, builders and contractors in the United States are slow to adopt proven energy-efficient construction practices. Some would argue that a more focused education effort would solve the problem. We would argue that performance standards for housing would move builders much more quickly along a path toward improved energy efficiency, better indoor air quality, and fewer problems with degradation of the thermal envelope.

4.5.1
Beginning steps

At the very least, buildings should be subjected to thermal scans and blower door testing. Then builders and consumers alike would begin to have a basis for making comparisons between structures, especially in regard to energy efficiency and healthful building design.

Is it not strange, then, that the houses we live in have few performance standards associated with them? What is a 'tight' house? How many air changes per hour should a house have under natural conditions or at 50Pa of pressure? How many cubic feet of air per minute should be supplied to each occupant? How well should building materials fit together, who will measure the 'fit', who will enforce the standards? In the future, we may see regulations which prevent power companies from connecting up structures that test below acceptable levels of efficiency, or perhaps banks will request higher interest rates on loans used to finance buildings that test below certain performance standards.

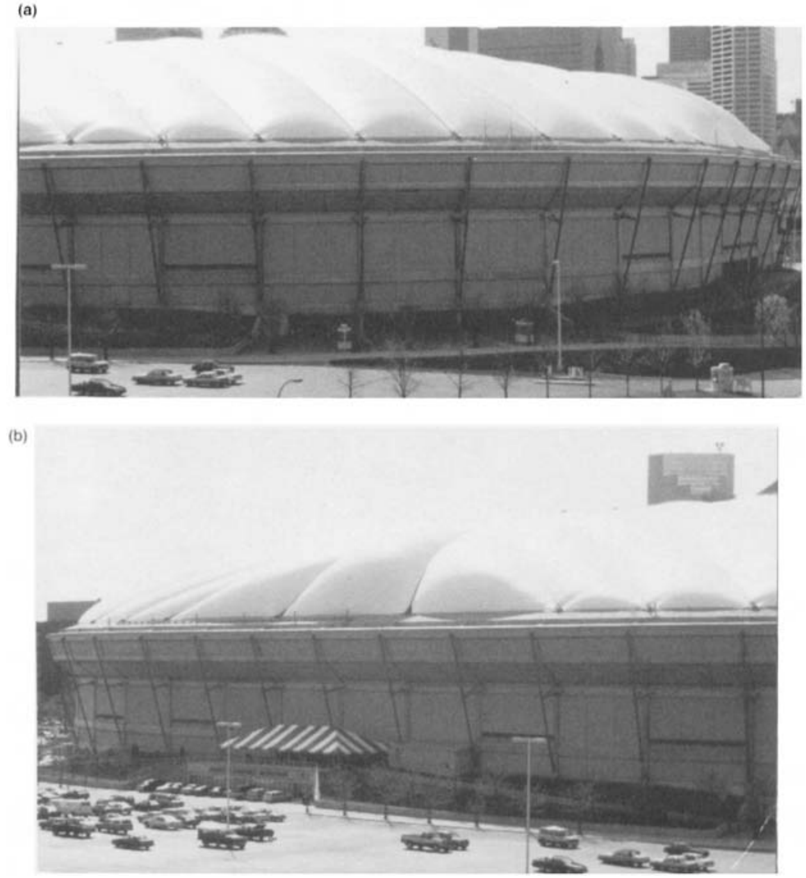

Figure 4.9 Two views of the Hubert Humphrey Metrodome, Minneapolis, which is a sports facility. The dome is inflated with air.

4.6
2000 AND BEYOND

As we look to the 21st century and the decades beyond, the evolution and application of performance standards—for building products, components and systems, and finally for the building itself—represent important concerns in building envelope design. As this evolution unfolds, considerable attention will need to be given to pressure differentials across the building envelope, these differentials being largely responsible for building deterioration problems that are increasingly apparent. Clearly, automated 'integrated' heating and ventilation systems are required, so that heating and ventilation appliances work together to ensure safety, indoor air quality, and proper pressure differentials.

What does the future look like? How is it linked to the present? The trend is indicated by two domed structures currently existing: a sports facility, the Hubert Humphrey Metrodome in Minneapolis (Fig. 4.9a, b), and Biosphere 2 (Figs 4.10 and 4.11), which is located near Tucson, Arizona. Biosphere 2 is a self-contained sealed environment. The concept includes the construction of several biomes—rainforests, savannahs, oceans, deserts—which serve as the main ecological 'building blocks' of the biosphere. One hundred years from now, both structures will be viewed as crude attempts to deal with adverse environments. But today they represent forerunners of what cold climate envelopes may resemble.

Figs 4.12 and 4.13 represent artist's impressions of how each structure might evolve in the next millennium.

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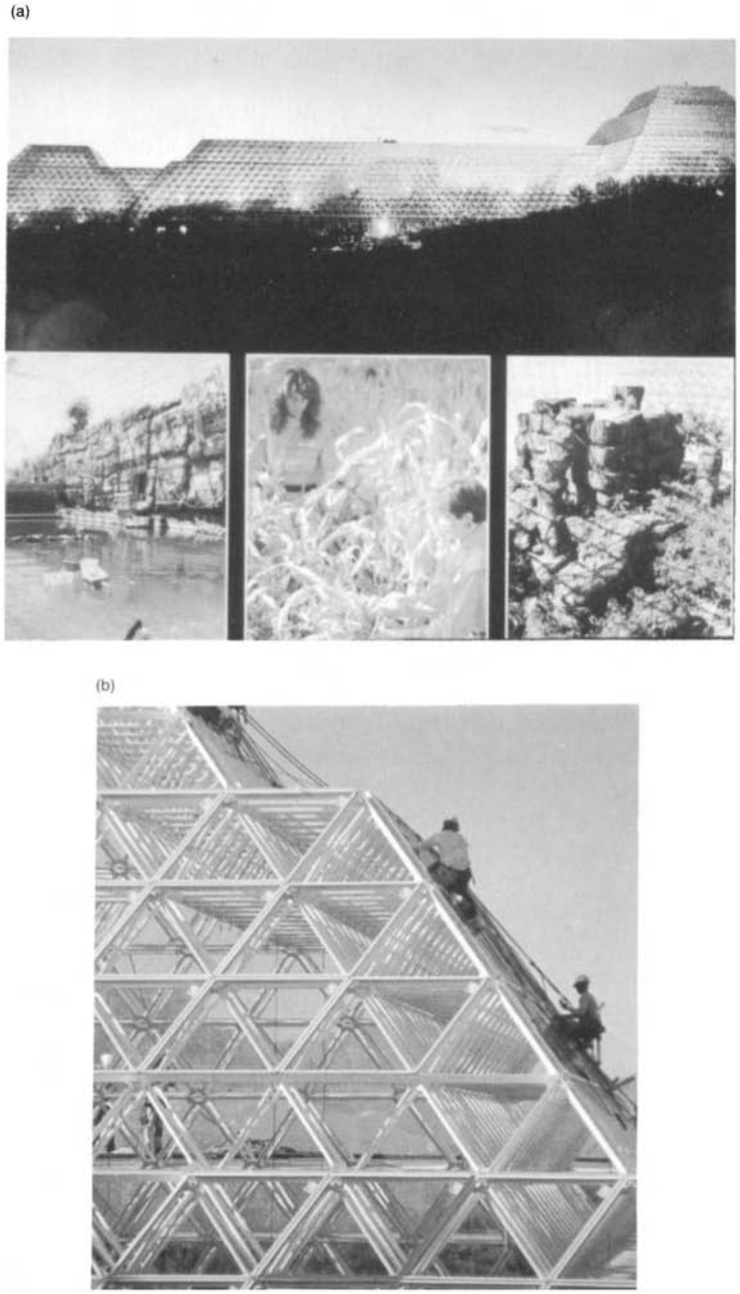

Figure 4.10 (a) Biosphere 2: the Human Experiment near Tucson, Arizona (Allen, 1991). (b) The spaceframe construction workers complete a part of Biosphere 2.

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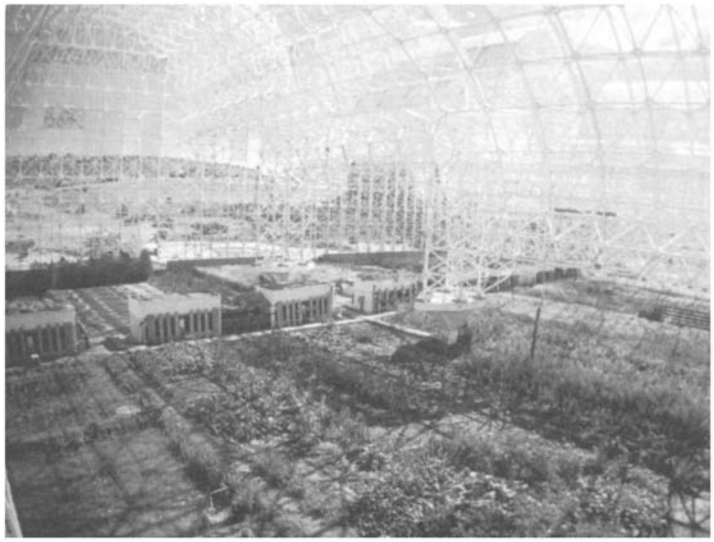

Figure 4.11 The core of the intensive agricultural unit in Biosphere 2 (Allen, 1991).

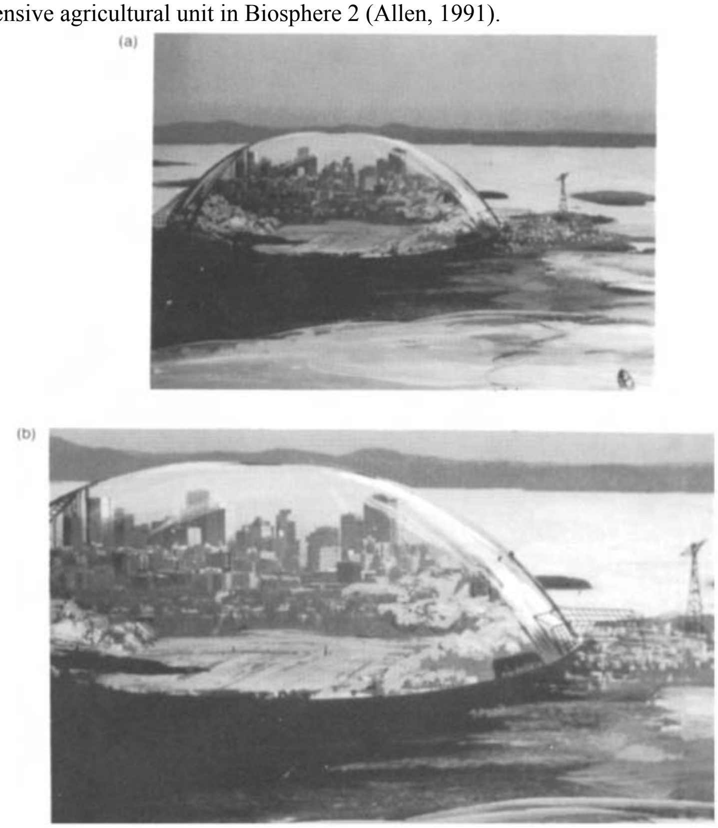

Figure 4.12 Artist's impression of a domed city in an extreme cold climate region.

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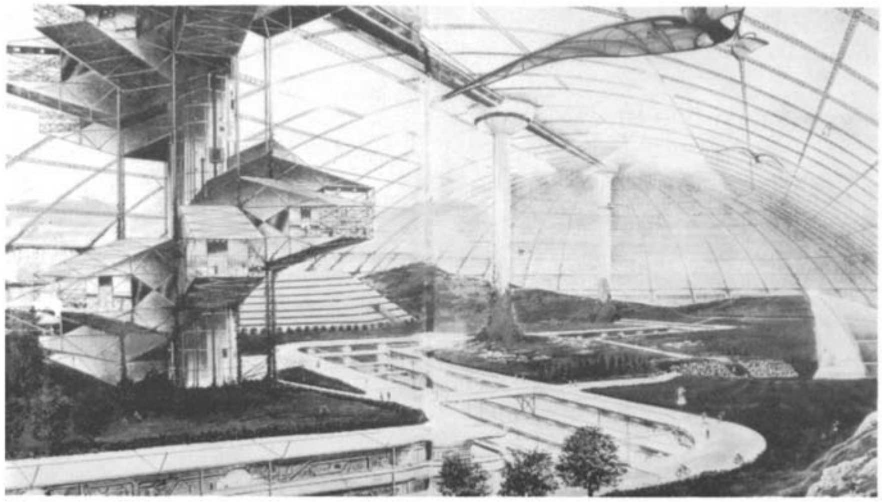

Figure 4.13 Artist's version of a biome in a cold climate region.

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5
Housing as an evolutionary process; planning and design implications

F.C.D.Vigier

5.1
INTRODUCTION

In the industrialized countries, housing is designed and acquired as a finished product. Whether as tenant or owner, households occupy a dwelling whose minimum size and amenities are prescribed by laws that are rooted in the government's traditional responsibility to safeguard public health and safety. The rising price of shelter in the Western world resulting from the enforcement of improved sanitary and construction standards has been accompanied by the development of complex financing mechanisms to maintain its affordability. These range from the availability of construction financing that keeps a developer's equity to a fraction of the building's cost, to housing mortgages for home ownership, to rental subsidy programmes for low-income tenants. In all cases, the result has been to keep monthly payments within a defined range and to enable households to live in dwellings they could not have afforded had the full construction price been paid in a lump sum. Even though the housing conditions of our urban poor are far from satisfactory, a variety of means are at our disposal to ensure adequate shelter; our too frequent failure to utilize them is due more to a political or ethical failure on our part than to an absence of the necessary financial resources or institutions.

The production of housing in the rest of the world is very different. Rapid, and for the most part uncontrolled, urban growth has been the salient characteristic of Third World countries for over two decades. Initially due mainly to migratory flows from rural areas, the positive balance between urban birth and death rates is now the principal vector of urban growth. As a consequence, all developing countries will continue to experience sustained demand for urban housing in years to come. From 1988 to the end of the century, the urban population of low- and middle-income economies (exclusive of China and eastern Europe) is expected to grow by 176 million people, nearly five times the urban growth of the high-income countries. This is roughly equal to 30 million dwellings.

Concurrently, the recent deterioration of the economy of all developing countries, most often as a result of circumstances well beyond their control, has forced the curtailment of social programmes, including those pertinent to housing. Diminishing resources have had to be allocated to servicing the foreign debt and supporting the price of basic commodities. The World Bank's 1990 Report, starkly subtitled Poverty' points out that one-fifth of the world's population is 'struggling to survive on less than $375 per year.' It is against this background of 'hyper-urbanization' and poverty that we need examine the production and consumption of housing in arid and tropical zones.

After their independence in the years following World War II, all but the poorer countries undertook ambitious public programmes to provide adequate shelter to their growing urban population. Initially inspired by European models, they consisted of flats in four- to five-storey walk-up blocks. From their inception, they were too expensive for all but the upper middle class. The remainder of the urban population was left to fend for itself and, in the sixties and early seventies, squatter settlements, shanty towns, and illegal subdivisions, all on unserviced land, pre-empted underdeveloped urban land. This trend remains largely unchanged in spite of vigorous efforts by governments to develop serviced sites, legalize tenure and provide existing neighbourhoods with infrastructure and community facilities. Even though the illegal occupancy of land has become less frequent, with the notable exception of India, Pakistan, and some Latin American countries, its illegal subdivision and development are now commonplace. In most countries, this 'informal' housing sector is responsible for 60–80% of annual housing starts. Investment in land and shelter, often fuelled by the remittances of expatriate workers, has become the main channel of domestic savings in countries where political instability and high rates of inflation compound an ingrained distrust of banking institutions.

The construction of housing has repercussions that extend beyond the provision of shelter as it plays a major role in the economy of developing countries. Inclusive of the informal sector, it is estimated to account for about a third of gross fixed capital formation, sometime reaching as much as 40%, as was the case in Jordan when it benefited from the 1975–85 economic boom in the oil exporting countries of the Gulf. This double function of housing as both shelter and investment elucidates the process of its incremental construction.

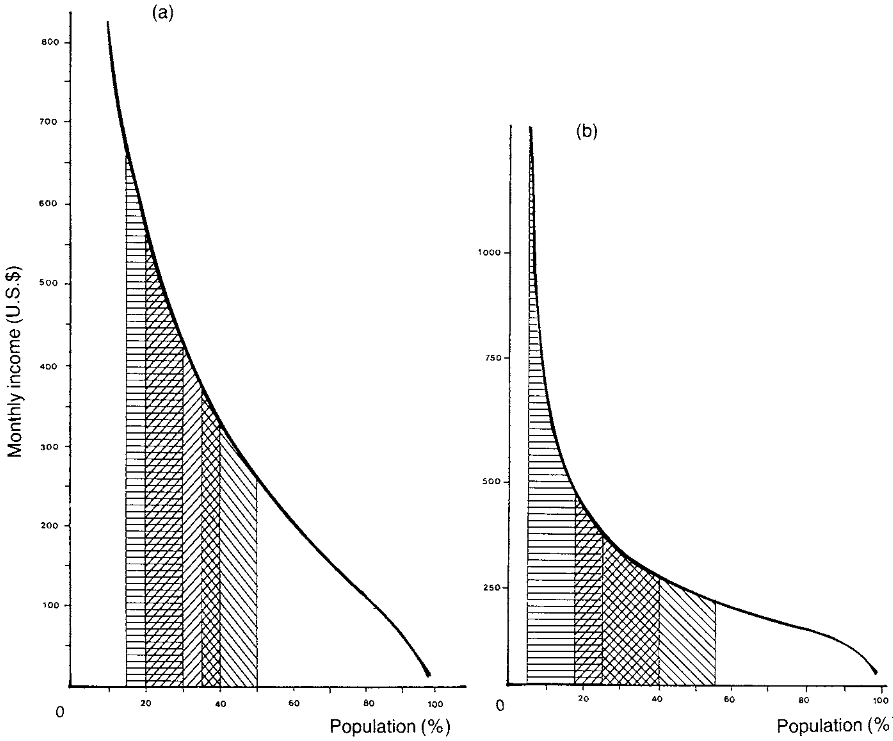

Figure 5.1 Affordability of housing in (a) Morocco and (b) Côte d'Ivoire. unserviced site, serviced site, social housing.

With the exception of public sector employees, civil servants, the armed forces, and the police, who, in many countries, still benefit from generous public subsidies, government-built turnkey projects are beyond the means of roughly 75–80% of the population. The economic gap between the cost of a dwelling constructed by a public agency and the rent or mortgage paying ability of urban households remains insurmountable, even with concessionary financing terms. The lowering of standards, from finished dwelling to core house, to a bare serviced plot, narrows this gap but marginally. In all developing countries, the price of an unbuilt site or dwelling meeting even minimal standards of sanitation is beyond the means of a majority of the urban population. Furthermore, any form of financing, even when provided by government, presupposes a relatively steady income; yet, anywhere between 30 and 50% of the urban labour force is not employed in permanent or secure jobs and is therefore ineligible for housing loans.

For example, heavily subsidized programmes of the seventies and eighties were affordable only to the 30% of households earning the highest incomes in Morocco (Fig. 5.1a) and to the top 25% in Côte d'Ivoire (Fig. 5.1b). Even when provided with long-term mortgages at interest rates well below those available from financial institutions, core houses on $100m^2$ serviced lots require an initial equity and monthly payments that exclude 65% of urban households in Morocco and 62% in Tunisia and small serviced lots are beyond the means of 55% of urban households in Morocco, Tunisia, or Côte d'Ivoire (Abdulac, 1988; Serageldin *et al.,* 1989; Vigier, 1987). Repeated efforts to break this income barrier have proved generally in-effective despite shrinking plot sizes, which, for example, have been reduced to $35m^2$ in a current World Bank financed project in Chittagong. Even though government programmes still account for a third or more of national housing investment, they rarely manage to produce more than 10–15% of new dwellings. Public programmes are increasingly targeted to the middle class, and housing for the poor is now limited largely to relocation projects.

5.2 THE DEVELOPMENT OF LAND BY THE INFORMAL HOUSING SECTOR

The growing inability of government to provide either housing or serviced land affordable to the middle class explains the emerging role of the informal sector as the major producer of shelter in developing countries. Unlike the squatter settlements of the fifties and sixties that illegally occupied land deemed undevelopable, today's informal housing is built on the urban fringe, outside areas scheduled by the government for infrastructure extension programmes, that is where the land is still relatively inexpensive. Title to the property is obtained through legal or paralegal transactions but is not registered with the authorities. The development of these areas follows a strict economic logic and their popularity lies in the flexibility with which individuals can invest their savings incrementally and gradually improve the size and quality of their dwelling.

The purchase of a plot is determined by the dynamics of a land market dominated by middlemen who lay out unserviced subdivisions: small-scale land speculators in Latin America, the Near East and North Africa, tribal chiefs in sub-Sahara Africa and parts of South East Asia. The development potential of the land depends on the availability of a nearby source of water —a well, stream, or spring—or, in its absence, an organized network of water vendors. It is clear from our review of the experience of several countries that households try to purchase as much land as possible, preferring distant locations to ones closer in, and cheaper unserviced land to more expensive serviced plots. Land prices will rise quickly as settlement progresses: they will roughly double within a year or two, increase by a factor of eight to ten if the area has been designated for upgrading, and reach 20 or more times their initial price when serviced with infrastructure. The acquisiton of a large plot is therefore viewed as a sound investment and its subdivision or the expansion of the dwelling to provide rental units invariably accompanies rising land prices.

Surveys of households in informal settlements have shown that an amount roughly equivalent to 1.3–1.5 times the yearly income can be mobilized from a variety of sources to accede to home ownership: personal savings, loans from family members, the sale of the wife's dowry of gold and silver jewellery. Over half this amount is generally spent on the land and the balance on construction. Boundary walls are built first to ensure possession, then a rudimentary shelter although, in most cases, the construction of a small permanent dwelling starts quickly. Additional rooms are built as resources become available, and are usually leased to a tenant to provide the income required to pay back the small contractors who carry out the work and who provide short-term financing for up to half the construction cost.

The ability of households whose income is below the median to generate the capital needed to become home owners is in sharp contrast to the prevalent unwillingness to spend more than a fraction of income on rents. Given that the cost of a medium sized unserviced lot on the fringe is less than half the smallest serviced sites provided by the government, only the lower 30–40% of households are excluded from the informal land market.

It should be noted that these developments are quite unlike the settlements built by rural migrants in the fifties and sixties; it is the work of an urban middle class looking for ways to improve their living condition and whose enterprise compensates for the public sector's housing failures. This is all the more remarkable since the lack of a registered property title excludes them from the credit markets. Yet, the development of large quantities of housing by individuals is a mixed blessing; the incremental transformation of small houses on small lots into increasingly dense urban neighbourhoods is accompanied by a sharp deterioration of environmental quality. Even though the dynamics of the informal land market in all developing countries is remarkably consistent, urban housing typologies differ, and reflect cultural and climatic characteristics as well as other ecological constraints. In tropical countries, the availability of a greater variety of inexpensive local construction materials gives rise to different housing typologies and development strategies than in arid regions. The underlying cause is the greater choice of locations provided by abundant water sources. Land prices on the urban fringe tend to be lower and the plots available in informal subdivisions are substantially larger than in countries where water is scarce. The examples that follow illustrate processes that are fairly typical in the construction of urban housing in both tropical and arid climates.

5.3 HOUSING TYPOLOGIES IN TROPICAL CLIMATES

With the exception of Latin America, the economies of the tropical countries are among the poorest of the world; yet they show striking variations, with 1988 gross national product per capita varying from $170 in Bangladesh, to $440 in Indonesia, to over $1000 in Cameroon or Gabon. (World Bank, 1990). The experience of the West African country of Côte d'Ivoire whose per capita income of $770 puts it at the lower end of the 'lower-middle income economies', is typical of countries which achieved considerable economic progress in the seventies and early eighties. Their more prosperous years triggered a wave of urban expansion that has yet to abate and the phenomenon of incremental housing transformations is clearly evident.

Abidjan, the capital, is growing at an annual rate of 4% and will reach 3.3 million by the end of the century. In 1988, 57% of its population lived in incrementally developed one-storey housing compounds built of cement blocks with sheet metal roofing. Several households, often related by clan or tribal kinship ties, each live in one- to three-room dwellings grouped around a common court used for cooking and for the compound's pit latrines and bathing stalls. On main streets, a part of the frontage may be sublet to a shopkeeper or craftsman who does not live on the premises. In central locations, the plots are small, ranging from 100 to 150m^2 and are laid out in rectilinear blocks, usually serviced with running water, electricity and on-site septic systems, more rarely by sewers. On cheaper fringe land, they commonly reach 400 to 600m^2 in area.

Regardless of location, the development process is strikingly consistent. The owner starts by fencing in the lot and contracts out to a builder the construction of several one- to two-room dwellings built of salvaged material nailed to wood frames or of cement blocks, according to his resources. He will initially live in the largest unit and lease out the others. Rents vary according to location, number of rooms and the quality of construction. In spite of its higher cost, most owners choose concrete block load-bearing walls with a corrugated tin roof supported by rafters. Surveys conducted in 1983–84 showed that, in spite of the lack of services, rents were comparable with those in the heavily subsidized 'social' housing projects constructed by the state until the economic recession of the early eighties forced the privatization of public housing agencies. Monthly rents varied from $15.60 for a wooden dwelling to $28.10 for a concrete dwelling on the periphery and $47.80 for one near the city centre. (The average monthly household income in 1984 was $225 and the minimum wage was set by the government at $109 (Agence d'urbanisme d'Abidjan, 1984).)

Housing compounds are highly profitable and, in a few years, the owner will have moved to a more desirable location and more units will be added to the fully rented compound, often achieving a surprisingly high lot coverage of 80% or more and reducing the original courtyard to little more than an air shaft. For example, the construction of seven one- and two-room concrete block dwellings on a $500m^2$ unserviced parcel on the periphery of Abidjan would have required an investment of $4410 in 1987 and yielded a yearly rent of $2680; an attractive propositon indeed, which encourages owners to densify the property to its maximum holding capacity. As a result, most dwelling units are small, 10–$12m^2$ for a one-room dwelling, 18–$23m^2$ for two rooms. Given average household size of 4.5 persons, net residential densities ranged from 500 persons per hectare on the larger peripheral plots of 720 or more persons per hectare in older subdivisions whose desirable proximity to the city centre had encouraged their maximum development.

The housing compound is particular to Africa and reflects still durable kin and tribal group relationships; but a very high lot coverage with one-storey buildings is prevalent throughout the tropics. It is to be found in the *kampung* of Jakarta, the *katchi abadi* of Karachi, and in the transformations of core housing projects in Dacca. The results are particularly unhealthy as rudimentary on-site sanitary facilities in rainy climates are quickly over-whelmed by the rising number of users while inadequate ventilation turns the small, overcrowded dwellings into hot and humid environments, a culture medium highly conducive to a variety of diseases.

5.4
HOUSING TYPOLOGIES IN ARID CLIMATES

With the exception of government sponsored projects which have extended infrastructure to the urban fringe, mounting development pressures in the more arid regions have led to the large-scale conversion of land from agricultural to urban use. Small landowners, farming at high risk and with narrow profit margins, find it difficult to resist the lucrative offers of private real estate developers. Only highly productive farmland is likely to remain unaffected by informal development. The land is subdivided illegally and marketed unserviced, in violation of existing codes, and buildings are constructed without permits. The success of these subdivisons for the 'new suburbanities' of the Third World is ensured by the lack of available serviced building plots affordable to the urban middle class.

In Egypt, Jordan, and North Africa, these illegal subdivisions have proliferated over the past decade, and are tolerated by local authorities unable to cope with a rising housing shortage. Densities rise quickly and can reach over 600 persons per hectare in three- to four-storey reinforced concrete buildings, unserviced for the most part. In Rabat, for example, the land area in informal settlements has grown five- to sixfold in less than 15 years, and housing production averages 10000 to 12000 dwelling units annually, more than twice the number of units legally constructed by the public and private sectors combined. Only 3.5% of households have access to municipal water, either directly or from standpipes, and 40% have electricity. In Tunis, the informal sector was responsible for over 44% of residential land developed between 1975 and 1983. In Cairo, over 80% of housing starts are illegal and some 600 hectares of prime agricultural land is lost yearly to informal settlements, including eight-storey buildings built without running water or sewers.

The quality of these informal settlements reflects the desirability of the location and the income of prospective buyers. The high cost of land within areas where water is available keeps lot sizes within a 70–$150m^2$ range but a few choice parcels can exceed $200m^2$ in area. The circulation network varies: 5–8m wide streets, 2–4m alleyways and narrow deadend paths of less than 2m in width. Unhindered by building regulations, property owners add income producing space; in Rabat, for example, 40% have converted part of the ground floor into shops and workshops and 60% have added one- or two-room rental units.

5.4.1
The evolution of the dwelling

The construction of the dwelling anticipates its enlargement through successive transformations. The prevalent building type is a relatively expensive reinforced concrete post and beam system, deliberately chosen to allow for the future construction of several floors, the only expansion strategy permitted by the small plots. A recent investigation of the densification in several informal settlements in Rabat illustrates the logic of the process (Rowe and Schodek, 1989).

All buildings consisted of a limited array of spatial components of similar size: a larger multipurpose rectangular room located near the entrance continued the tradition of the *salamlek* of the Islamic house; one or more smaller rooms, either square or rectangular, used as sleeping quarters or leased to tenants; a sanitary facility; more rarely a kitchen. Floor to ceiling heights were consistently 3 m for the lower level and 2.5m for upper floors while the free span dimension of rooms varied

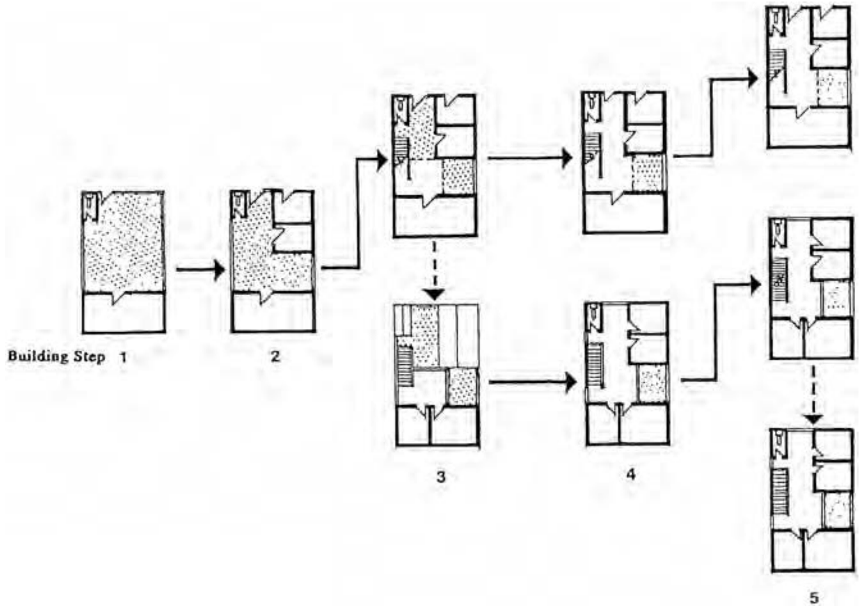

Figure 5.2 Spatial evolution of an informed dwelling in Rabat; ( ) open ground, ( ) open roof terrace.

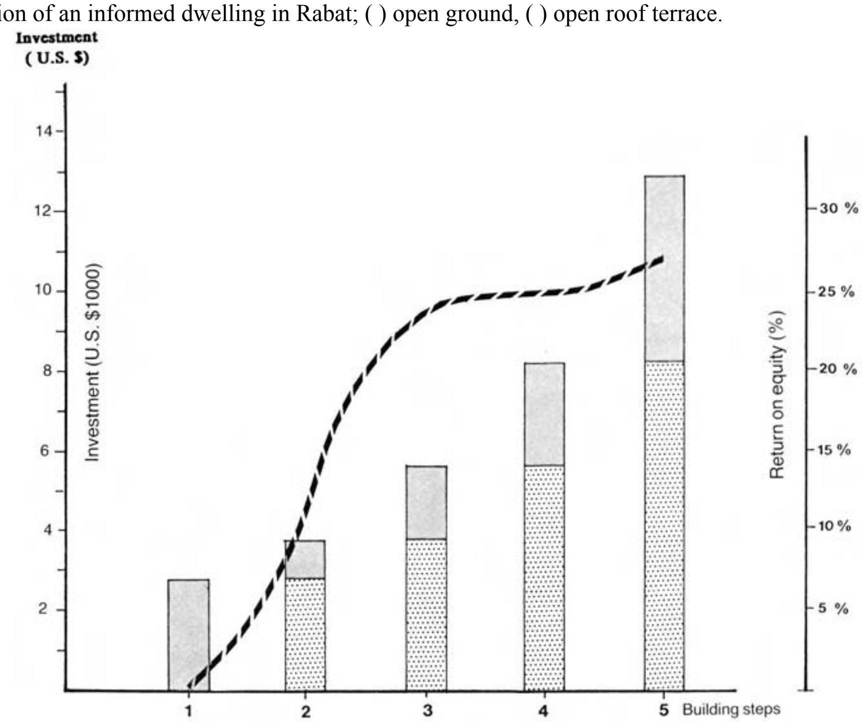

Figure 5.3 Investment strategy for an informal dwelling in Rabat. The broken line is the return on equity.

between 2.5 and 3.0m to minimize the need for imported reinforcing bars. The selection of a particular plot development strategy reflects the owner's financial resources. For example, the initial addition of rooms on the ground level requires a relatively small investment as only a light roof is used, often built of salvaged material; conversely, the cost of a concrete slab is immediately capitalized upon by building a useable space, usually for rent, on the new load-bearing roof. The use of this simple architectural vocabulary allows the development of building configurations whose generalized syntax is shown in Fig. 5.2.

Fig. 5.3 illustrates the logic of the process by tracing investment flows and the return on investment at each step of the development process. The initial purchase of a typical 100m^2 lot and the construction of a one- or two-room dwelling with a light roof, and of a sanitary facility, requires an investment of approximately $2750, well within the means of Rabat households whose earnings fall within 10% of the city's median income. (1987–88 costs, incomes and rents for Rabat, Morocco, are used in this analysis.) The addition of two additional rooms for rent, one of which would be let out as a shop or

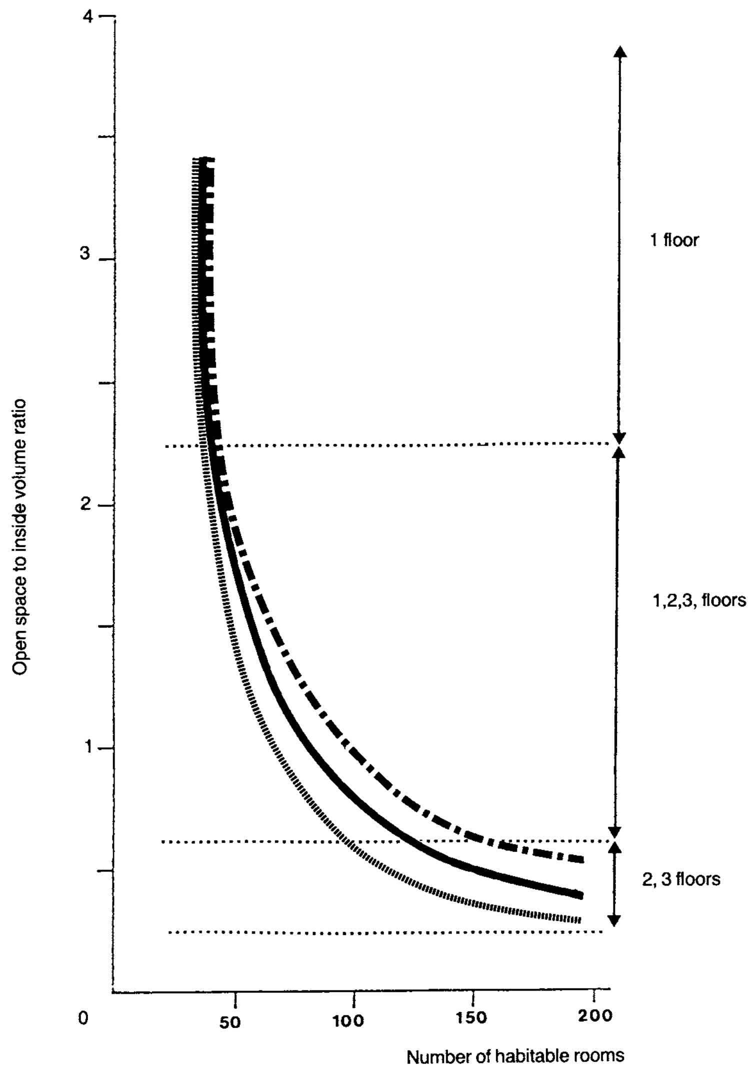

Figure 5.4 Passive ventilation index. The index 'assumes that the number of air changes likely, under normal passive conditions of ventilation, are largely a function of the ratio of the enclosed to the open volume of the house, for any given level of 'porosity' in the building envelope introduced by openings such as windows and doors.' (Rowe and Schodek, 1989, p. 35.) Lot size: (▮▮▮▮▮▮) 5×12m^2, (▬▬) 6×12m^2, (▬ ▪ ▬) 6×14m^2.

workshop, requires an additional investment of $1000 and would be within the means of households with incomes 10–15% above the median. This second step is critical as it starts to generate income at a rate roughly equivalent to a 10% rate of return on investment. Depending on the mix of savings and borrowing used to finance the construction, the owner will be ready to build additional floors in two to three years.

Step three consists of replacing the light roof with a load-bearing reinforced concrete slab and building a stair. The cost involved commonly leads to its division into two phases. Initially, a $1850 investment to add a partial first floor will nearly double rental income, yielding a return on investment of 24% on the total cost of the property. Within 18–24 months, the remainder of the first floor will be built and the additional rental income will have increased the return on investment to 25. 5%. A second floor will be added later, as soon as sufficient capital has been accumulated. The initial investment has now grown to over $12000 and will yield a 26.9% return on investment if the owner has not expanded his living quarters.

The vertical expansion of the dwelling is accompanied by a sharp deterioration of ventilation in the lower floors as the original courtyard shrinks. While the ground floor structure in step two had a floor to open area ratio (FAR) of 0.4, the completion of the first floor increases the FAR to 1.8 and that of the second to 2.7. (The FAR is a common indicator of the intensity of development; it is calculated by dividing the total floor area of the building by the area of the plot.) This situation is worsened when one looks at the consequences of the vertical expansion of contiguous parcels within a block. Fig. 5.4 plots the ratio of open space providing ventilation to inside volume of a built mass as the number of habitable rooms increases; the built mass consists of two rows of 13 plots on either side of a street. As density rises and additional floors are added, the potential for passive ventilation diminishes rapidly and increases the likelihood of the spread of respiratory diseases, even in dry climates with cooler nights.

5.5 CONSEQUENCES OF THE DENSIFICATION PROCESS

The informal housing market of the seventies and eighties contributed a much needed addition to the urban housing stock and was often hailed as a panacea for the failure of governments to sustain the expenditures needed to shelter a rapidly growing urban population. A closer look at the results of the densification of these settlements through successive transformations reveals a number of disturbing factors affecting the quality of life, both within the dwelling and in the settlements themselves.

Paradoxically, densification is the product of the current economic recession in the Third World. As land prices have soared and urban incomes have stagnated (or actually dropped, in real terms) the rising ratio of seed capital to income required to acquire and develop a parcel of land has decreased the percentage of urban households able to accede to home ownership and forced them into the rental submarket. Informal settlements have been the main beneficiaries of this trend as owners were quick to capitalize on the income potential of this new demand by adding rooms f or rent to their dwellings (Serageldin, 1990). The incremental cost of an addition to an existing structure is marginal, relative to the initial investment required to acquire a parcel of land.

Harvard's Unit for Housing and Urbanization is currently undertaking field tests to quantify the poorly understood linkage between the health of the urban poor in developing countries and the environmental conditions in which they live. Our hypothesis is that the configurations of dwellings developed by the informal sector are major contributors to the respiratory, gastrointestinal, and parasitic disease that are associated with urban povery. (The World Health Organization estimates that five million deaths and two to three million cases of permanent disabilities could be prevented each year if housing conditions met safe levels (WHO, 1987).) The preliminary analysis of our recently completed survey of health conditions in a Karachi *katchi abadi* shows intriguing correlations between morbidity rates, particularly in children, and the volumetry, temperature and humidity of the dwelling (D'Souza, 1991).

At the scale of the city, as land values rise, we are witnessing successive transformation of the urban fringe into dense, unserviced neighbourhoods, whose mix of housing and economic activities invariably leads to environmental pollution. In spite of an often regular layout, the narrowness of their public ways and the proliferation of structures on subdivided lots increases the cost of providing them with public services. Their eventual upgrading necessitates expensive adjustments to the city's infrastructure improvement plan and will, in turn, refocus new development to other, more distant and unserviced locations.

Increasingly limited budgets have prompted local authorities to undertake partial infrastructure improvements. The revenue potential and relatively low cost of water distribution networks often lead to the provision of water service before sewering. While individual septic systems are usually adequate in areas where water consumption is low, the introduction, often politically motivated, of piped water without sewering invariably causes a sharp deterioration of sanitary conditions. The resulting increase in per capita water consumption from 8–10 litres per day, when water is fetched from a standpipe or bought from a vendor, to 70–80 litres per day once the dwelling is connected to the network, stresses septic systems well beyond their design capacity and causes overflowing and seepage. In Tunisia, for example, 84% of urban dwellings were connected to the state electrical network in the early 1980s, 71% to the water distribution system, but only 51% were sewered (Vigier and Amiot, 1982).

The inability of local government to control and shape urban growth, coupled with ineffective cost-recovery strategies, have made the task of providing infrastructure and public services more expensive. Financial constraints have discouraged routine maintenance and municipal authorities commonly respond only to crisis situations, as materials, tools and trained personnel are in short supply. Even revenue-producing water and electricity systems cannot sustain maintenance expenses from tariffs and user fees; the resulting high leakage losses further diminish potential revenue and exacerbate the financial difficulties of each utility. While international funding has been readily available for capital investments, maintenance has been viewed by donors as a purely local responsibility. It is only in the past few years that infrastructure maintenance loans have been available from the World Bank.

5.6 OPTIONS FOR THE FUTURE

Housing in developing countries transcends the building envelope and the failure of local authorities extends to broader issues than housing. Insufficient funds and poorly trained personnel, the large areas that have to be monitored, the difficulty of enforcing such development control techniques as zoning and dimensional regulations, which are viewed by the local population as idiosyncratic and culturally inappropriate, undermine the usefulness of traditional Western approaches to planning and urban management.

The inability of local governments to control the forces that are shaping the city is not only due to a lack of financial and managerial resources. The diversity as well as the scale of urban expansion poses substantial technical problems. Primary local data sources, such as building permits and property tax records, are not updated to reflect the densification of older districts through the subdivision of properties and the uncontrolled and largely illegal development of fringe areas. Municipal officials are left with the thankless task of an *ex post facto* documentation of an urban growth rate unprecedented in history. In the absence of adequate information, the ability to monitor change, to plan and manage the city, and guide development, decreases steadily.

The challenge faced by national governments and local authorities alike is to regain some measure of control of a highly dynamic process, primarily to safeguard the public health, as a growing percentage of the urban population does not benefit from urban water supply and sanitation. This situation will become more acute as budget constraints have led to widespread curtailments in capital investments which, in developing countries, have typically been on the order of 10% of the GNP (Cook and Austin, 1988). As a result, new residential construction will continue to occur on unserviced land developed by the informal sector.

Finally, governments have been able to provide few incentives to convince people that adherence to specified development standards is in their best interest. Even though the upgrading of unserviced areas is welcomed by the population, in spite of the inevitable displacement that accompanies the widening and straightening of streets to allow the construction of utility networks, the collection of improvement fees and connection charges is always difficult. Recent experience shows that only 50–65% of public infrastructure costs are recovered (Serageldin, 1991).

I believe that three complementary changes in public policy are required to allow local authorities to regain some measure of control over urbanization and, simultaneously, reinforce the ability of the private sector to build housing and improve its quality.

5.6.1 An active government role in the land market

Past government intervention in the land market focused on the regularization of illegal occupancy, on providing a limited number of serviced sites and on upgrading existing settlements by providing them with infrastructure. In the last two instances, the requirement of bilateral and international lending agencies to recover the investment from beneficiaries has excluded a growing proportion of the urban population from these projects or required substantial public subsidies. Moreover, the sharp increase in property values that accompanies infrastructure improvements is captured by property owners, often land speculators, and 'lost' to the authorities, given the difficulty of collecting property taxes in the absence of up-to-date property records.

A renewed government interest, and participation, in the urban land market as a whole, rather than in specific projects, may offer a fruitful avenue to counter the private speculation that underlies the housing activities of the informal sector. Large reserves of land should be acquired on the urban fringe, divided into plots and eventually sold to the public. As is the case in the informal market today, cash land sales would be for its 'fair market value', as determined by its location relative to existing and future infrastructure networks.

The ability to capture rising land values, or at least that portion deemed socially acceptable, would provide a steady stream of revenues, unabated by inflation. The public acquisition of land and its resale to individuals, even unserviced, would allow its subdivision at standards appropriate for the eventual introduction of utilities; secure sites for community facilities, elementary schools in particular; and protect fragile ecological features. It also encourages the search for innovative design solutions, including alternative sanitary technology.

The large-scale intervention of the government in the land market will be anathema to advocates of privatization. Yet, its merits are undeniable if undertaken by an autonomous and self-financed specialized agency that is unable to tap into central Treasury funds. There are examples of successful non-subsidized public land developers in both industrialized and developing countries: the London Docklands Corporation, which successfully launched the redevelopment of a most difficult area with limited public funds; the Massachusetts Housing Finance Agency, which depends on its own bond issues to finance the construction of housing for low- and moderate-income families; the Société Nationale Immobilière Tunisienne, which, in spite of its focus on turnkey projects, has maintained a remarkable financial autonomy for over ten years. The list of agencies that have operated only with substantial government subsidies would of course be much longer. But in most cases, their failure to attain financial autonomy was due to their being assigned conflicting objectives or to a mandate that required them to provide a broad range of housing subsidies as part of their normal operations.

5.6.2
The introduction of incremental infrastructure

The high cost of providing infrastructure to unserviced areas is often due to inordinately ambitious, or inflexible, engineering standards. Sanitation projects have a substantial foreign currency component, typically of the order of 60% of the cost of primary networks (Serageldin, 1989); this is no longer affordable to many countries in the present economic situation of the Third World. Yet, the curtailment of infrastructure investment cannot be sustained for any length of time without aggravating the threat to public health. The lesson to be gleaned from the incremental improvements that are typical in informal sector housing offers interesting alternatives to large infrastructure projects.

There are several promising intermediate sanitary technologies, ranging from communal septic tanks to oxidation ponds, that are inexpensive and require little or no foreign currency (Arthur, 1983; Kalbertmatten *et al.,* 1980). They have not been used to any extent as they require a careful synchronization with the division into plots of land that has not been possible, given the disjunction between the process by which land is developed by the informal sector and the activities of departments of public works. The public developer described above would be responsible for undertaking low-cost sanitary improvements in conjunction with the laying out of subdivisions. Initially making extensive use of intermediate technology, they should be readily upgradable and incorporated into modern networks as densities rise. The cost of the initial system would be recovered as part of the land price and subsequent charges for upgrading the system would be modest, as compared with the current practice of going from unserviced to a fully serviced site in one step.

5.6.3
Regulating the development of informal housing

Preventing the detrimental effects of successive transformations of the dwelling poses a more daunting problem. We have seen that the deterioration of ventilation standards resulted largely from the configuration and size of rooms relative to the geometry of the site and city block. Given the innate economic logic of the building densification process, it should become the cornerstone of any attempt to regulate it. Here again, the size and shape of lots produced by a public developer may help, but additional measures are needed.

The repetitious use of similar building forms in informal housing is clearly not accidental. Rather, as in any culture, they have become standardized stylistic models, selected by both owners and builders as practical and symbolically appropriate. The new owner in an informal subdivision will be influenced not only by what is already built but by what the small local contractors in the area are accustomed to build. In the absence of alternative incremental construction models, the detrimental health conditions in the dwelling that accompany rising densities are either not foreseen or, probably, even deemed significant.

Public authorities should assume the responsibility to provide alternative building typologies that can be expanded and improved over time, vertically as well as horizontally, in accordance with the household resources. Their construction must be simple enough to match the skills of local builders; their design must reflect the lifestyle of an urban middle class whose culture still reflects traditional values, partly rooted in the countryside. The design of housing prototypes that are competitive with current practice in informal settlements has been largely ignored by architects who insist on viewing housing as a finished product rather than an evolutionary process.

These ‘models’ of a new domestic architecture can be popularized by offering the incentive of government financing for their construction, not with subsidized, long-term mortgages but through short-term, market rate construction loans. Financing that reflects both the real cost of money and the incremental investment strategy actually followed by the informal sector need not drain public resources as the quick roll over of construction loans would constantly replenish a revolving housing financing fund. It also provides local authorities with an effective regulatory mechanism: additional loans would be granted only if the existing structure meets specified standards. Financing informal housing has the additional advantage of increasing the rate of construction of rental units and easing the urban housing shortage.

5.7
CONCLUSION

The new housing policies described above will not remedy the existing deterioration of Third World cities; damage to public health, to the environment, is too extensive to be redressed quickly with the limited resources at our disposal. After all, it has taken the industrialized countries nearly a century to demolish and replace the unsanitary urban housing constructed during the Industrial Revolution. By combining the resources and energy of individual home owners and more realistic government interventions, they may simply help prevent the continued spread of housing that is destined to become little more than a slum.

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6
The home of tomorrow: communication and control

P.Chemillier

Until recent history, say before the middle of the last century, housing was not much more than a shelter to protect the inhabitants from various types of aggression: inclement weather, people, animals.

There were few amenities; insufficient windows provided mediocre lighting during the day, candles and oil lamps afforded the same service at night, hearth fires provided poorly distributed heat while water for cooking and washing had to be brought by hand.

Technical progress, as a result of the Industrial Revolution, improved the quality of the shelter provided. The paraffin lamp was developed, the wood or coal stove replaced the hearth. Progress in glass-making increased the dimensions of windows and improved lighting.

But the first major revolution in domestic comfort came with the appearance of running water, gas, electricity and, more recently, central heating. What used to be called the 'electricity fairy' in France not only modernized the lighting of homes but also led to electrical appliances which were a mark of considerable progress in the life of the housewife.

It is important to note that these improvements to the comfort of housing were only possible as the result of the considerable change which occurred in the relationship between housing and the environment, through the creation of various public networks: electricity, gas, clean water and waste-water.

In terms of communication, an important step had been taken; each home became dependent on a local authority and, as a result, had to pay electricity, gas and water bills.

Gradually, ways were found of controlling the amenities that, by completing what was originally only a shelter, had improved living conditions: control valves on hot water radiators, adjustable window blinds, mixer taps on baths and wash basins replacing two separate hot and cold water taps, controlled mechanical ventilation.

With regard to communication with the outside world, the telephone, and more recently, the television set, have brought radical changes. Relations between those inside the home and the outside world have developed considerably.

Energy conservation, which has been a major concern since 1973, has led to new progress in control mechanisms: e.g. thermostatic taps on radiators which can be adjusted according to the room temperature, thermostats inside or outside the home to control the operation of boilers to maintain a specific indoor temperature, heating installation programmers, rheostat lamps, air exhaust fans with variable flow rate based on the humidity of the room, thermostatic taps on wash basins to produce programmed water temperatures.

In the field of communications, fax machines, the French 'Minitel' videotex system, telephone answering machines, remote-controlled access to housing, all indicate further progress.

But all these 'products', which have multiplied and been perfected, are independent of each other. It has seemed to be a good idea to connect them up by using an internal network, so they could (i) communicate with each other and with outside networks, (ii) make certain polyvalent equipment multi-purpose, and (iii) monitor it all with a more or less centralized 'intelligence' system which makes optimum use of the complementarity of the different types of equipment used and settles any conflicts which may arise between them. This internal network must also simplify all the wires, sheathes and plugs which have mushroomed and allow for subsequent developments without having to add wires or knock down walls.

This in France is what we call 'domotique' or home automation. A distinction is generally made between several systems.

The security system includes the following: surveillance of homes and detection of intrusions; detection of faults, e.g. gas or water leaks; surveillance of people (children, elderly people) from inside or outside the home; medical advice from a distance.

The control system is used to monitor the different operating parameters in the home: heating, air conditioning, ventilation, gas, electricity.

The domestic help system is designed to facilitate the various domestic chores: cleaning, washing clothes, cooking, watering, opening and closing shutters and blinds.

The communication and information system relates to the telephone, fax and telex; it also concerns audiovisual equipment and is designed to control and connect up television sets, video cassette players, hi-fi equipment.

All these systems can provide a large number of functions. For example, remote control of various features in the home via the telephone network: opening of windows, operation of electrical equipment, heating, lighting; sending of messages via the telephone network to indicate a fault in the home: gas or water leak; access via the telephone network to water, gas, electricity, telephone usage.

The component parts of these systems are networks and data detectors or sensors. Let us take a closer look at the networks. Modern homes have three networks: (i) a low voltage electricity network; (ii) a network of very low voltage weak currents (telephone, intercom, alarm); (iii) a video network connected to a coaxial cable (television, hi-fi).

Communication with the outside (pictures, sound, telephone, electricity supply) is provided by four networks: the radio network, the telephone cable, the power cable and the coaxial cable or optical fibre.

In home automation, internal networks are 'integrated', i.e. they ensure the smooth coexistence and convergence of the different data flows. One solution to the problem of integration is a numeric domestic code (binary unit system) (BUS) for communication between all the systems.

Several physical carriers can be envisaged for the BUS:

1. The power cables, which have the advantage of not entailing any additional installation costs, of allowing users to acquire their equipment gradually and of being easy to use; each item of equipment is connected to an outlet via an interface. However, both the flow and type of data routed and the possibility of interactivity are limited.
2. Telephone wires, which also have limited capacities, but can be used to set up a baseband network and transmit data in conversational mode.
3. The coaxial cable (television cable) for the transmission of video signals. It can be used to set up a broad band network and can route all types of messages, e.g. pictures, voices, data, controls.
4. The optical fibre, which has very large capacities, but is currently handicapped by its price and connector problems.
5. Links without physical carriers (infrared, ultrasound, radiofrequency, hyperfrequency), which do not raise any installation problems, but whose capacity is limited, but which can result in interferences and come up against legal restrictions.

Interfaces complete the domestic BUS and require the existence of exchange protocols among the different components, all of which must be independent of the physical nature of the links.

Detectors or sensors play an essential role since they supply the different systems with information. The efficiency of the equipment depends on their quality. They fulfil various functions: detection of temperature; metering of electricity, gas, water and heating oil; detection of a presence; detection of intruders; fire detection.

This field has been the subject of a large number of research projects and,

Table 6.1 The intelligent home: sociocultural trends. Hierarchy of the most interesting specific functions (in percentage of people interviewed who found each function interesting)

Specific functions requested	*Average*	*France*	*FRG*	*UK*
Technical management and control of risks (system)	56	59	61	48
Security—protection (system)	51	50	36	66
Control of mod cons	48	53	43	48
Assistance	36	46	37	25

today, various detectors and sensors are available whose technology we cannot go into here.

Home automation appears to be the end result of a long process of evolution, where the concept of the house as a shelter has developed into that of a provider of services. Various examples exist in Europe, Japan and the United States. Considerable interest is being shown by technicians in home automation, but we can hardly speak of a significant breakthrough. What are the future prospects in this field?

First of all, it is interesting to look at the results of a survey carried out in 1987–88 by *Market Office* in France, Great Britain and West Germany involving 900 people, who were asked to express their degree of interest in the various functions required of an intelligent home. A hierarchy of functions emerged very clearly (see Table 6.1).

Another interesting survey was carried out in 1988 by EDF, the French electricity authority (see Table 6.2).

The surveys carried out and the resulting analyses have brought out several f actors which must be taken into account in evaluating the prospects of home automation and encouraging its development.

1. It should be noted that there is no spontaneous demand on the part of the inhabitants. It is therefore through a supply strategy on the part of professionals (manufacturers, etc.) that the market will develop. But therein lies the difficulty. The product being sold is not like a brick or a boiler. It is not self-contained; its usefulness depends to a large extent on the social environment. A remote alarm system in the case of fire is only effective if it is connected up to a team of people capable of rapidly taking action. None of this can be tested in the laboratory. If someone wants to promote a particular

product, he must be prepared to take risks and proceed with caution. He must surround himself with advisors with a new type of profile, such as sociologists.

Table 6.2 Perception of functions

Functions	*Positive replies (%)*
System to prevent accidents in the home	88
Programming of heating according to hours of presence	83
Control of correct operation of household appliances	78
Permanent monitoring of energy consumption	75
High-performance surveillance system for burglaries and attacks from the outside	75
Air-conditioning system	69
Automatic household refuse disposal system	65
Possibility of remote teaching courses	65
Bank account management by videotex	62
Air purification system	62
System for switching lights on and off according to the presence of the occupants	61
Possibility of receiving worldwide television channels	60
Picturephone	57
Possibility of working at home using a computer	54
Remote monitoring system	53
Possibility of composing balanced meals	52
Remote triggering of heating	49
Mobile partition wall system	42
Microcomputer for children's homework	36
Robots to do housework	34
Remote watering system	32
Telephone in each room	29
Medical self-diagnosis by telephone	29
Automatic pet feeding system	28
Shopping by videotex	26
Control screen in each room	23
Television screen in each room	10

2. A supply strategy will naturally be favoured by the existence of standards, to ensure that new products are compatible; this alone can lead to large-scale distribution and lower prices. But on the other hand, it is a new field in which creativity has an essential role to play. The relationship between man and technology plays a very important role. It is unlikely that the right solution will be found if the standards are too restrictive.
3. It is difficult to develop new products and services if they are designed to replace existing products and services which currently fulfil similar functions. Co-existence is necessary if people are not to be frightened off. The situation is similar to that of hard currency; coins and notes have gradually been replaced by cheques and now by magnetic cards, but without any actual rupture, and today the different systems exist side by side.
4. The emphasis should not be on the innovative aspect. References to the 'home of the future' or 'the home of the year 2000' cause a reaction of rejection or, in any event, suspicion. Men and women today live in a complex, aggressive world, which is constantly changing under the effect of technical innovations. There is an underlying feeling of anguish, which can be seen in various ways: social unrest in large housing schemes, the fight against technology, that could prove hazardous to health, public awareness of environmental problems. Ecology is developing in a context of deep concern.

The home is the last 'stronghold' of private life in this distressing universe. The inhabitant does not want technology to pose a threat. He will only accept it if it brings relief, if it makes life easier, if it calms his fears, such as those caused by the difficulty of communicating in a world where families are broken up and dispersed.

The risk of rejecting innovation is still greater in rented housing, particularly low-income housing estates; in this case, the introduction of systems such as those mentioned above is often designed to facilitate the task of the person in charge of running the estate and consequently is considered by the tenants to be a further threat to them.

The new technology must not be visible (cables, computers, sensors) since, on the whole, the inhabitants are not interested in how it works, nor do they have the capacity to understand it. This has several repercussions: technical equipment must be very reliable (just as people today are no longer interested in looking at their car engine nor in understanding how it works); the after-sales service in the event of a breakdown must be rapid and moderately priced; the technology-inhabitant interface must be as simple (user-friendly) and convenient as possible.

'Intelligent' homes must be personalized, even more so than ordinary housing. This is one of the marks of their intelligence. Just as when buying a car, the supply must include: a few basic modules corresponding to certain basic functions which meet a common demand for a large group; a series of options which can be ordered either at the time of purchase or later.

This combination of options and a basic formula gives the buyer the impression that he is personalizing his home. It has long been known that one of human being's deepest desires is to stamp out a territory.

When it comes to choosing options, it will be possible to give the home its dominant character according to the type of occupant: contact with the outside world for young couples, with the accent on communication and information; organization and good management for very busy people with little time to devote to household tasks; comfort and tranquility for middle-aged people; security against risks of all types for elderly people.

In conclusion, it appears that the main prerequisite for the development of home automation, which will make it more than a series of electronic gadgets, will be its capacity to be the instrument of projects for the good of society; this will contribute considerably to increasing its value.

The home is not just a house, that is, a space in which people live. It also includes the environment, that is, the relationship established by the inhabitant with the leisure activities available, local shops, work, etc.

In the traditional habitat, the inhabitant keeps within specific territories; their distance from his home depends on his displacement capacities. These territories are the suburb, district, town, region, etc., in which he lives. Each territory has its own services and decision-making authorities, all of which is organized in a fairly hierarchical way.

Within these different territories, he does not stand out as an individual. He is a member of a heterogeneous population. Home automation will bring a decided change in this respect. The territory concept will no longer apply. Highly developed means of communication will abolish the idea of distance; many things which today require displacement will be accomplished at a distance.

These same communication facilities will enable people with the same problems to be identified, forming a subset of the population. Thus the population will be divided into groups of people such as those over 70, housewives, etc. Specific services, adapted to their needs, can be proposed to each of these groups; exchanges can develop among the members of each group.

It is easy to imagine the consequences which these developments could have.

I pointed out earlier that, traditionally, a certain level of influence corresponds to each territory and a certain breakdown of functions has gradually been established for the different territories, either by the rules of social organization, or by people's habits. The change in the notion of territory will upset this balance and necessitate social reorganization.

The forming of groups of homogeneous populations with common problems could give rise to common claims and therefore encourage the formation of political lobbies.

I have mentioned the services that home automation could provide at a distance: diagnosis and care of sick people, intervention in the case of a burglar alarm, billing of electricity consumption, surveillance of young children, etc.

This naturally supposes that the organization of these services already exists and is efficient. But that is not enough. It must also be able to adapt itself to each individual case. A simple example will amply illustrate this. We know that, in low-income housing estates, the payment of electricity or heating bills poses problems to those running the estates since a certain number of people have financial difficulties. In current practice, these difficulties are solved through dialogue and the adoption of appropriate measures in each case. Any automatic system would result in serious social problems and therefore a rejection of technical progress, which is the exact opposite of what is being sought.

Home automation cannot be limited to technology, however attractive it may seem. It must be at the service of the user and prove its social usefulness. It will fail if technological capacities are expected to change practices and customs. It can, on the contrary, succeed and mark a new, positive stage in the development of housing if it provides the opportunity for a change in the social organization of the urban habitat. Intelligent housing presupposes intelligent towns.

7
Housing and advanced technology: towards a total housing system

N.Kashino

7.1
INTRODUCTION

There are less than 10 years until the 21st century. In the design of housing from now on, it is of course necessary that the designs continue to provide a space for resting, eating, and enjoying convivial family gatherings. New designs should provide barrier-free space and variability of partitioning, allow for the introduction of household-chore-performing devices, adopt new construction techniques, and cope with any new demands of society, such as those caused by increased population concentrations in urban areas or changes in labour practices accompanying the ageing of society and the escalation of land prices.

The conditions demanded have risen along with the affluence of society. In recent years, there have been conspicuous advancements in the preparation of menus for advanced technologies related to housing, beginning with new techniques concerning materials and practices, and including equipment and facilities possessing new functions. Technologies have advanced to the point that in the cases of certain materials it is possible for molecular design to meet the needs of the user.

These advanced technologies are considered to be very useful in enhancing the functions of housing. However, when taking up an advanced technology, it must be kept in mind from the outset that there will be both advantages and disadvantages.

In this paper, I present a brief sketch of advanced technologies in housing today, and my views concerning the starting points for the assessment of these technologies.

7.2
POSSIBLE ADVANCED TECHNOLOGIES FOR HOUSING

A question first arises as to what kind of advanced technologies there might be in relation to housing.

The representative advanced technologies for providing the basic performances required of housing—both detailed and multiple, and, moreover, including apartment housing which would allow the functions required in a future society to be enjoyed- are set out in Appendix 7.A (Kashino, 1988a, b; Architectural Institute of Japan, 1991). Appendix 7.A refers to technologies that are still under development. Designers and users would select appropriate technologies according to their requirements or preferences, and some of these technologies might be suitable for developing countries.

As is clear from Appendix 7.A, advanced technologies related to housing may be broadly divided into two categories: (1) new materials, framing and construction methods, and (2) new equipment and facilities.

With regard to (1), there are various new (raw) materials and combinations of them that reduce weight, and possess higher levels of functioning and greater performance. Furthermore, there are construction robots.

Waterproof humidity-permeable processed fabric and high-absorbency plastic could be used to reduce the damage done by dew condensation. High-efficiency thermal and sound insulation materials are used to improve the comfort levels of thermal and acoustic environments, and base isolation methods and ceramic fire protection materials improve the safety of buildings. Lightweight, high-strength members are used for urban-type high-density multistorey housing.

New materials (new raw materials) are often used to enhance the performance of buildings, such as their structural safety and their durability.

New framing methods, such as void slabs and suspension floors, are useful for creating new spaces, which can then be divided up by means of moveable partitions. The design of a building can be changed greatly by the introduction of new framing methods. Structural-steel-welding robots and tile-hanging robots have been developed to cope with shortages in skilled labour or as alternatives to monotonous or arduous operations.

With regard to (2), there are types of apparatus for labour-saving home automation and for self-diagnoses at home. There are also devices that enable housing to be self-sustaining when lifelines are cut; they purify waste water, generate electric power, and recycle water.

Figure 7.1 This type of house, with thatched roofing and thin mat walls, was very popular in Japan before the 20th century. This picture shows the backyard.

A relaxing environment can be created by a combination of several factors: rapid spot-cooling and heating, pleasant lighting, deodorizing filters; the acoustics of a concert hall may even be reproduced in the living room. Outside, the lawn and shrubs may be watered by an automatic sprinkling unit.

Healthy menus are cooked in a high-performance kitchen, and labour is saved in domestic chores by a laundry system and cleaning robot. Opening, closing, and locking of doors and windows are all done by push button, and bath water can be heated remotely. Space may be more efficiently used by means of automatic storage lockers.

The application of computers continues. For example, there are intelligent facilities that can check blood pressure and test urine samples.

Although advanced technologies for optimizing the safety and durability of a building may be welcomed, it will be necessary to keep in mind that such advances may require an excessive consumption of energy. It may be nice for labour to be saved in doing domestic chores, but the quality of life is not necessarily enriched.

7.3 THE TOTAL HOUSING SYSTEM: WHERE TO BEGIN THE ASSESSMENT

Generally speaking, the term 'total system' often implies that the system has been set up in a manner that results in all the conditions demanded being satisfied. For example, a 'total system' may comprise a good living environment with adequate structural safety and durability, barrier-free space and gently rising stairs for the elderly, and systematized kitchens and home automation. In other contexts, a 'total system' may mean efficient septic tank systems that use biotechnology, solar energy collectors, and private power generating facilities.

It appears that increased efficiency and convenience are usually implied when referring to 'total systems'.

Needless to say, it is important to improve the safety and durability of a building, and to consider conveniences that would be helpful for the elderly. However, if the term 'total' is to be used, it is necessary to consider the relationship between the housing and its environment, for example how the housing's appearance affects this environment. Also, further destruction of the regional environment should be prevented by conservation of resources and energy.

It is important to think of the 'environment' as meaning everything other than one's self. Any attempt to improve convenience and efficiency for one's self means further depletion of resources and energy and an increase in the amount of CO_2 gas released, all of which implies deterioration of the environment somewhere. We must seek a suitable balance between the pursuit of convenience and the inevitable load upon the environment, that this pursuit implies.

How did housing construction change 1000 years ago, 500 years ago, 100 years ago, 10 years ago? (See Figs 7.1–7.4.) Actually, styles and functions of buildings have only changed significantly during the past 10 years. In Japan, the Western table-and-chair style of living has increasingly set in, which, together with the spread in use of new materials and practices and the general acceptance of the introduction of new computer-controlled devices, has resulted in considerable changes.

Until about 100 years ago, the materials used were natural, and drawing of water for cooking and heating by an open fire were commonplace (Fig. 7.3). There was hardly any change in the spaces for sleeping, eating, and relaxing. Because materials

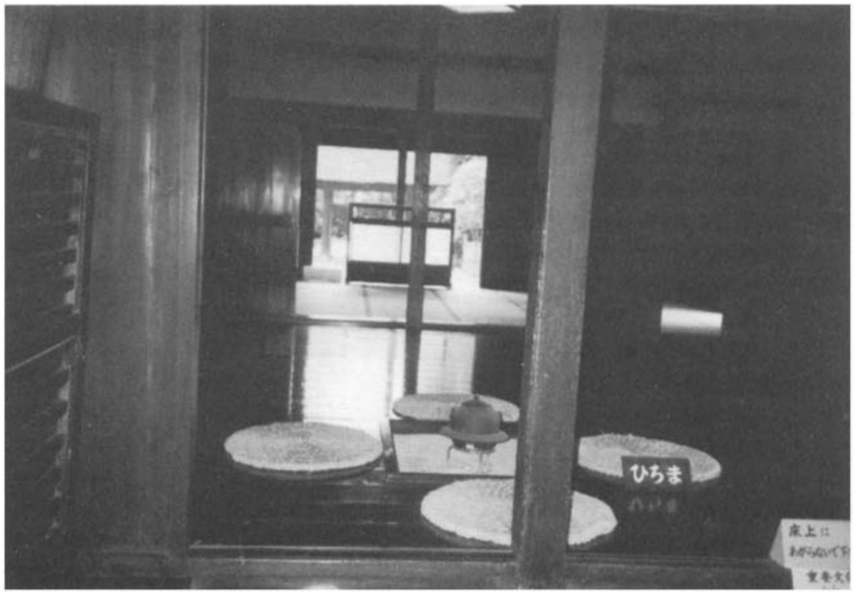

Figure 7.2 The living room of the house shown in Fig. 7.1, where the family sat around the fireplace in the middle.

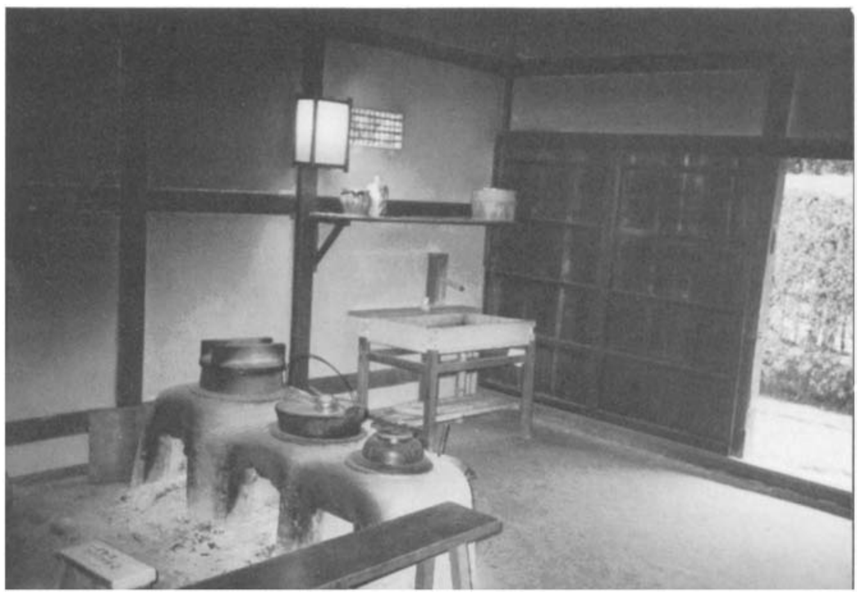

Figure 7.3 An older type of kitchen. (This house is in Simiju Park, Chiba-ken.)

were natural, their qualities were constant, and maintenance was a cooperative concern. For example, in case of roofs, people would get together periodically to rethatch them.

During the past 100 years, the table-and-chair style of living was introduced, and the automobile civilization has set in. The infrastructures of urban areas have gradually changed to meet the demands of the automobile. The types and styles of housing have proliferated.

During the past decade, opportunities for women within the workplace have increased, and, with saving of labour in household chores accompanying changes in working practices and increased densification of cities, there have been various kinds of facility developed. Individual housing units have been partitioned into small rooms of the highly closed-off type composed of diverse new materials. Living styles based on tatami mats and on tables and chairs co-exist, furniture overflows, and people have been forced to live surrounded by built-in facilities.

The shelter that people live in greatly affects their temperament (Kashino, 1987). The Japanese of today have come to expect devices to work instantly at the flick of a switch. In the future housing ought not to exaggerate such negative qualities as impatience and narrow-mindedness through an excessive reliance on active air conditioning (Kashino, 1987).

Figure 7.4 Natural wood beams and columns. Such natural materials have very good structural properties. Housebuilding techniques were similar throughout Japan.

I do not mean that there should be a return to the conditions of 100 years ago. But the fine traditions once possessed by the Japanese of careful use of resources and consideration of others should be remembered. This would help to create space which puts the occupant at ease, and help to build housing which incorporates innovations for preservation of the global environment.

In the construction of housing, both detached and multiple (medium-rise, high-rise), rather than concentrating on precision in matters of detail, the following criteria should be achieved: harmony with the environment; a flexible structural design, which leaves the interior design to the occupants; structural durability, which would avoid the 'build and demolish' philosophy (Kashino, 1984); devices for excessive convenience are avoided, such as apparatus requiring no effort in its operation; space owned in common for which residents have joint responsibility; passive air conditioning; and use of energy by a group of houses.

In the selection of technologies listed in Appendix 7.A, consideration must be given to the points mentioned above.

We can learn from housing environments of other countries, such as Hong Kong and Scandinavian. In particular, there is a great need to develop housing that is both comfortable and appropriate for the elderly and disabled.

The components of a country are houses, and the components of a house are people. It may be that in the 'total system' of housing, the concept of building people would also be included.

7.4 INTRODUCTION OF TECHNOLOGY

New technology must be assessed to see if it really will meet the objectives, and whether through its introduction there will be some kind of change in the biological functions and sensitivities of humans who are living in the housing.

Where new materials are introduced, their compatibility with the parent materials with which they are to be combined will have to be studied. For example, gaps can form between materials through differences in co-efficients of thermal expansion (Kashino, 1988b).

There are many cases of deaths of elderly people from falls on flat surf aces (Kashino, 1988b). If soft flooring material, such as artificial turf, were used to minimize the risk of injury on falling, a child who grows up in such an environment will acquire the habit of not cushioning a fall with the hands, so that there is an increased chance of serious injury if the fall occurs outdoors. It is said that in the Kansai Area, giddyingly steep stairs were installed in housing for the elderly because 'older persons need to build up leg power.'

It is also said there are children who think the smell of the fragrant olive is the smell of the toilet. This is probably because deodorants are similar to natural fragrances.

Built-in facilities are liable to collect dust and are difficult to clean. Strong detergents may damage furniture and facilities. For example, a certain type of alkali detergent removes stains well, but will also seriously damage anodizing films. There are, of course, pros and cons.

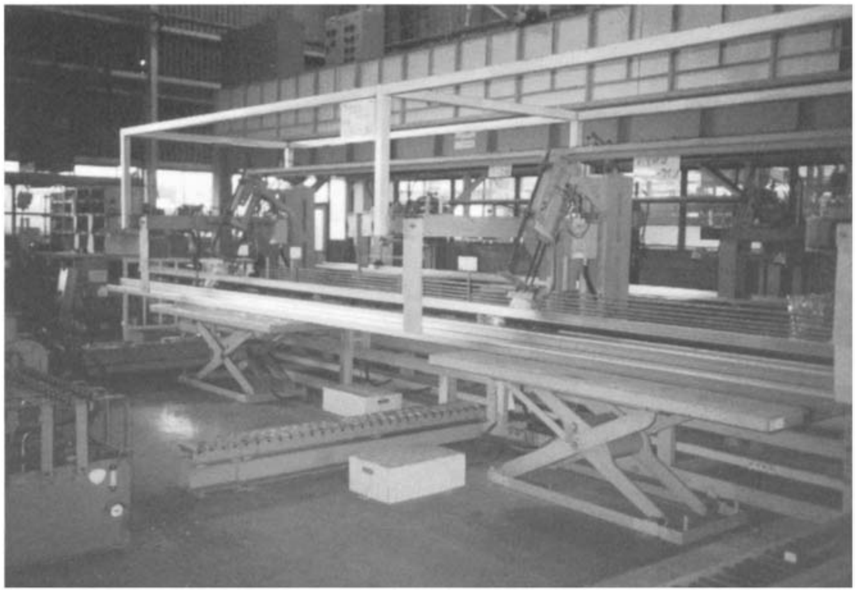

Figure 7.5 Preparation of metal materials for each building unit, comprising beams and columns (from Sekisui Haim Company).

Figure 7.6 Preparation of wood-based materials for the floor.

Appendix 7.B lists items in the forms of comparisons with Appendix 7.A thought to be starting points of assessment when introducing advanced technology to housing regardless of whether detached or multiple.

In addition to the features listed in Appendix 7.B, the dimensions and layout of the interior of housing will need to be reconsidered in view of the increased size of the Japanese physique. The impact of 'do it yourself will also need to be considered, as will comfort-related facilities, such as the removal of humidity from bathrooms.

Today, computer-aided design and robot-assisted manufacture facture of products are becoming more common in the quest for continued enhancement of quality and productivity (Figs 7.5–7.12). Such new technologies raise several questions. Do they come up to the raised st Standards of information processing: Is software suitable for design available? Are robots viable alternatives to monotonous, arduous and hazardous operations? Would a robot be easy for the aged and disabled to operate? What is the position of robot technology in architecture?

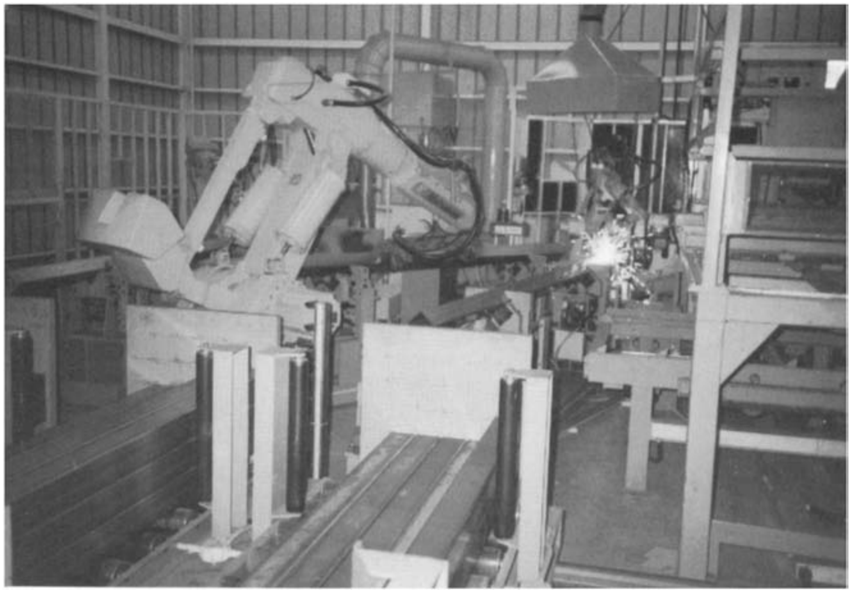

Figure 7.7 Edge welding robot for each metal building unit.

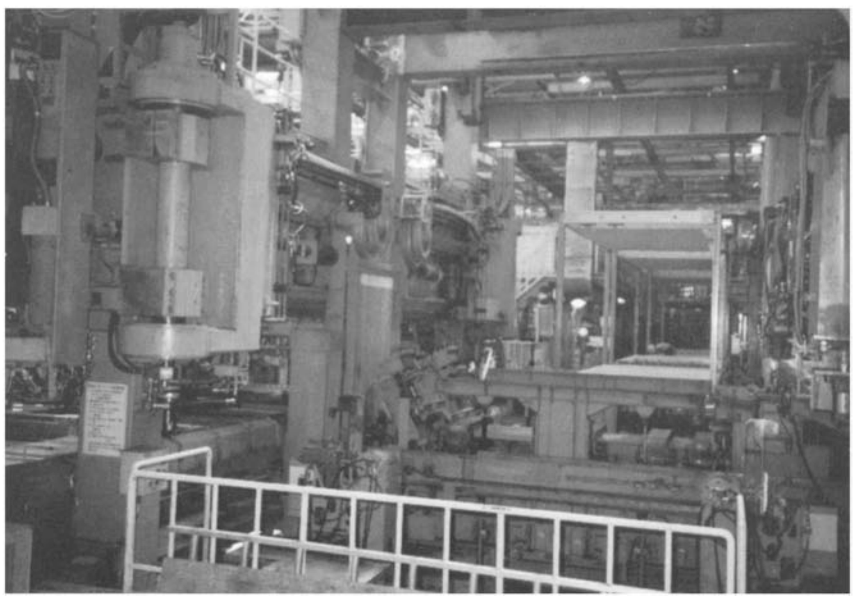

Figure 7.8 Robot assembling building elements. The basic unit of the house is prefabricated.

7.5 CLOSING REMARKS

In approaching the next millennium we should attempt to discern the universally demanded conditions for housing, and the future needs of society. We should aim to develop a housing which allows a comfortable life and which is in harmony with the global environment. (See Figs 7.13–7.22; also Kashino (1991).)

APPENDIX 7.A REPRESENTATIVE ADVANCED TECHNOLOGIES IN HOUSING

1. Selection of design (improvement of street view, scenery) *((e), (g), (h)*)*.

   (a) Antique-appearance concrete in harmony with the natural environment, expression of bare texture of concrete (contrivance of subdued colour and shape).

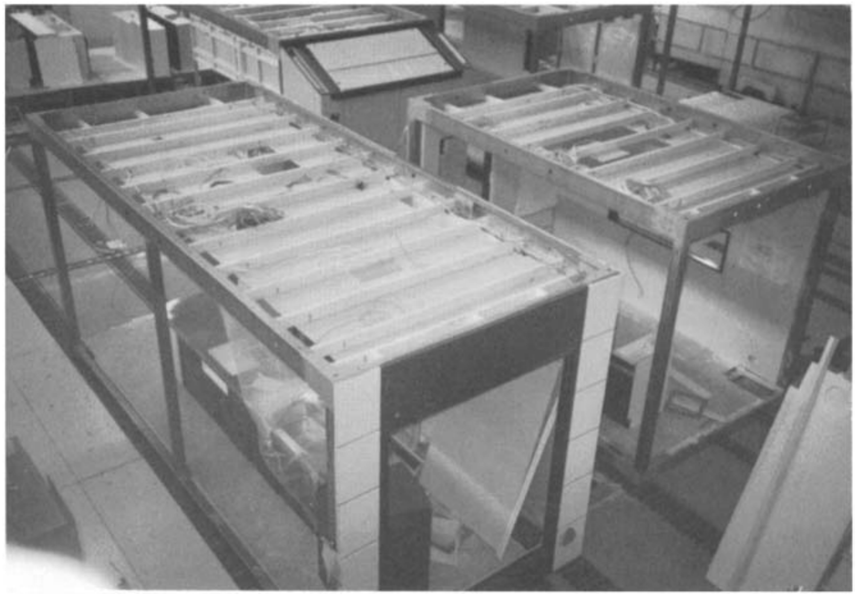

Figure 7.9 Completed basic unit of a house.

Figure 7.10 Assembled prefabricated building units.

Finish with texture imparting charm to high-density urban view.

2. Securing of good habitability (i.e. sound, light, heat, air, sanitation, spaciousness) *((a)–(h))*

(a) Artificial wood, waterproof humidity-permeable fabric, light-dimming glass, high absorbency plastic, shape-memory alloy sensor.

(b) Solar powered or water-driven compression heat pump air conditioner, sunlight-following natural illumination system, energy self-sufficiency, panel lighting, panel heating.
(c) High-efficiency thermal insulation for the roof and exterior walls.
(d) Intelligent refrigerator, chair, dresser, water closet.
(e) Artificial tree-planting technology.
(f) Built-in facilities in concrete panels, soundproof glass fibre pads, dew-proof concrete floor, light-transmitting concrete.

Figure 7.11 View of the inside of the house.

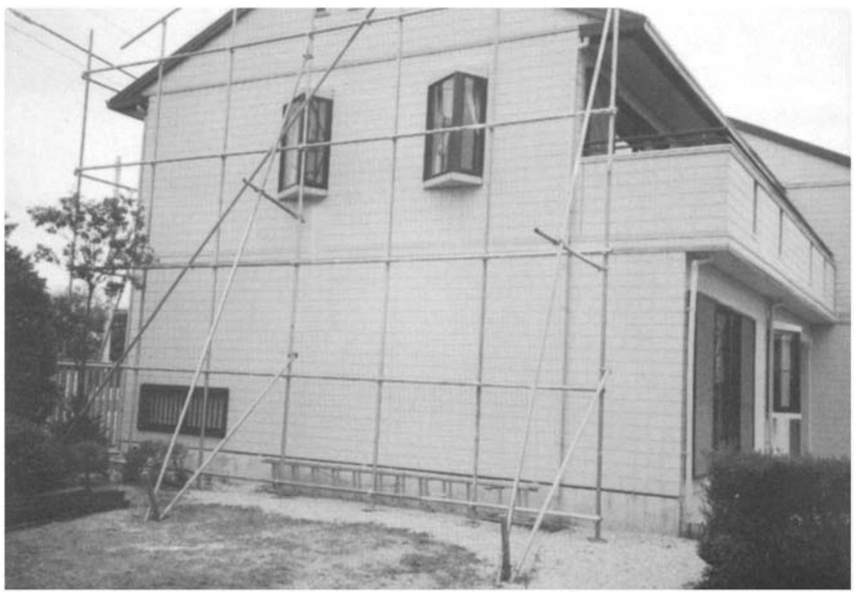

Figure 7.12 Sealing process for joints of units.

(g) Home theatre, home concert hall.

3. Securing of earthquake resistance of building structures, and conversion to multiple stories, reduction in weight *((e), (f))*.

   (a) Base isolation method, void shear wall.
   (b) New fibre materials, new metal materials, super lightweight aggregates, new ceramics, functional polymeric materials, large cross-section laminated timber.
   (c) Super light weight aggregate concrete, super high-strength light weight concrete, CFRC and other fibre-reinforced concretes, thin-shell steel-tube-reinforced concrete (CFT).

4. Provision of variable space (ease of remodelling, ease of changing use of space), three-dimensional housing unit, underground space utilization *((a)−(e))*.

   (a) Suspension floor.
   (b) Flexible wiring and piping systems.

Figure 7.13 A model of a 1.5–storey house, which uses the narrow spaces efficiently, e.g. folding bed, kitchen in the wall, etc. (from the Japan Architectural Center).

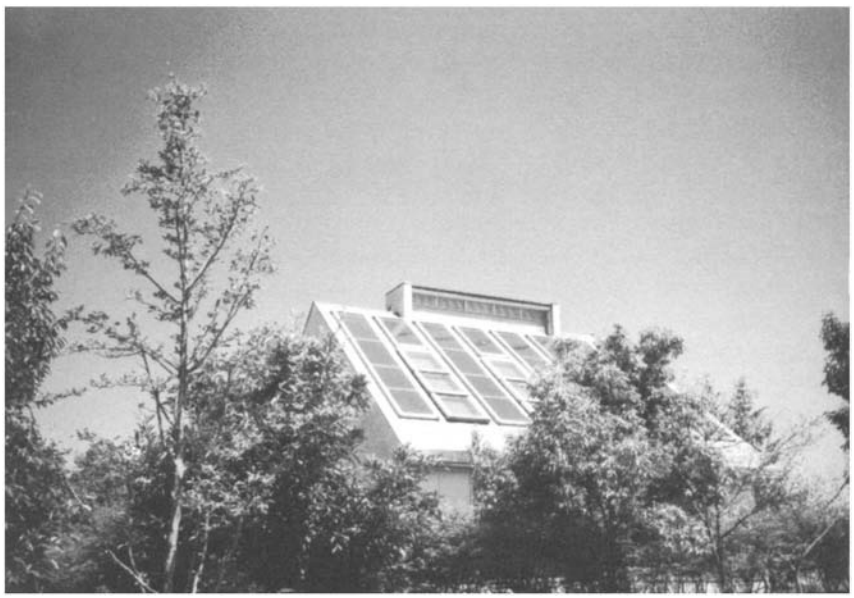

Figure 7.14 Passive solar systemed house. Windows in the roof open and close automatically in response to changes in indoor temperature and moisture.

(c) Super light weight concrete, built-in wiring, concrete partitioning.

5. Securing of safety against disaster (including disaster monitoring set-up, evacuation and secondary disaster prevention) *((a)−(e), (h))*.

   (a) Flame resistant ceramic concrete.
   (b) Heat-resistant smoke-proof sleeve (for through-wall, through-floor uses), home sprinkler.

6. Crime prevention *((a),(c),(d),(h))*.

   (a) Alarm system built into wall.
   (b) Computerized security system.

7. Building maintenance and preservation (including renewal) *((a), (d), (e), (f))*.

Figure 7.15 Model of so-called TRON intelligent house (Figs 7.15–7.20, from Nippon Homes Co.). Outside view of house.

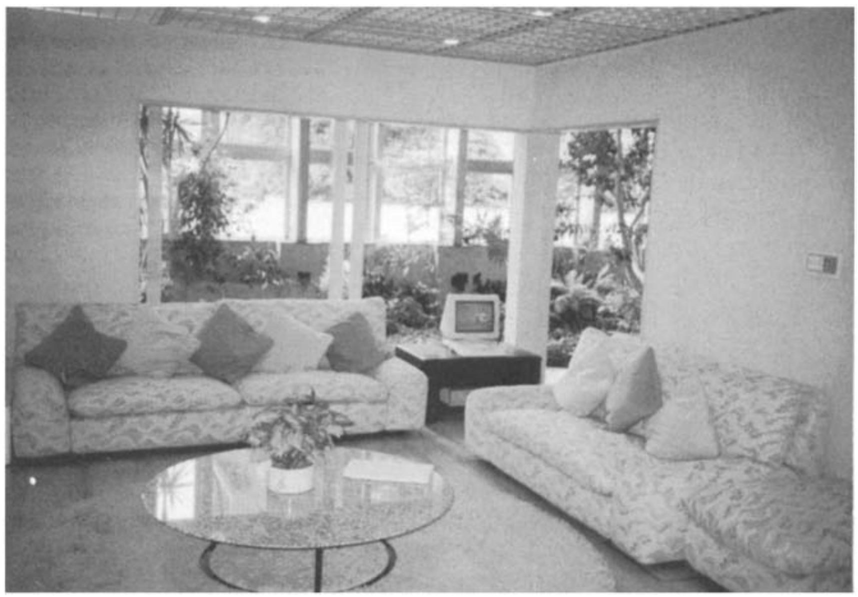

Figure 7.16 Living room of the TRON house, with air-conditioning, sound control and/or light control systems.

(a) Repair methods using new ceramics, functional polymeric materials.
(b) Detachable flexible concrete panels, special synthetic rubber concrete.
(c) Examination and diagnostic robot, material deterioration sensor (detection of exterior wall tile spalling, examination of cracking and separation of concrete, corrosion of reinforcing steel, equipment piping).
(d) Repairing robot (coating film separation repairing robot).

8. Securing of information processing functions *((a), (c)−(h))*.

(a) Telecontrol.
(b) Home BUS system (network termination).
(c) Concrete panel with optical sensor and various other sensors built in for housing, raised concrete floor system, electrically conducting concrete panel, radio wave absorbing concrete panel, harmful radio wave shielding concrete panel, concrete antenna.

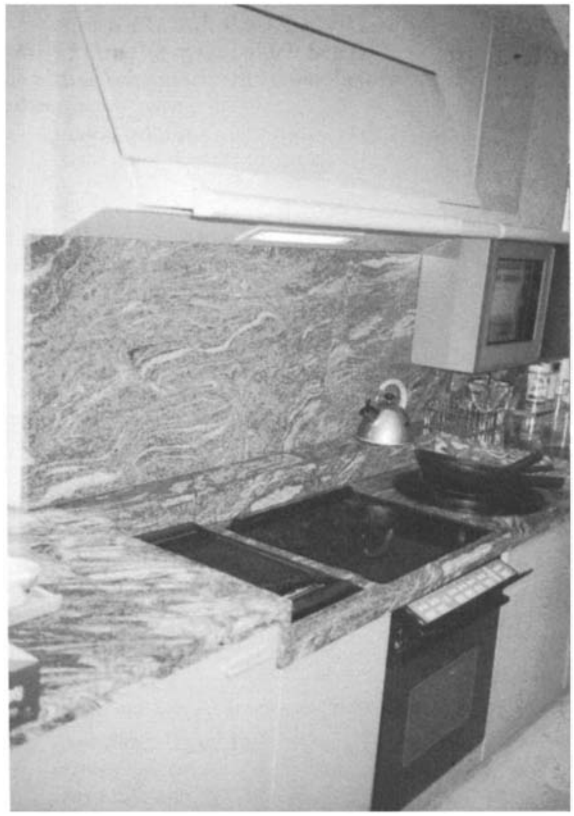

Figure 7.17 Computer-controlled kitchen—food preparation by the unskilled by following the TV monitor!

9. Measures for labour-saving in household chores (mechanization or change to outside services in cleaning, washing, cooking) *((a)−(d), (h))*.

   (a) Cleaning robot (floor cleaning, window-washing robot for high-rise building).
   (b) High-efficiency kitchen, laundry system and automatic garbage conveying system.
   (c) Difficult-to-soil interior and exterior finish materials, easy-to-clean-when-soiled interior and exterior finish materials.

10. Coping with the elderly in society *((a)−(c))*.

    (a) Free-access floor.
    (b) No-injury-from-falls floor.
    (c) Home self-diagnosis system.

11. Ground reinforcement *(e)*.

    (a) Geotextile.
    (b) New additives for ground acidity neutralization, ground stabilization.

12. Securing of drainage and sewage purification processing, waste matter disposal *((a)−(c), (e), (f))*.

    (a) Septic tank and garbage disposal incorporating bioreactor.

13. Design of building.

14. New construction, remodelling, and demolition of building, *((a), (c), (d),(f), (g))*.

    (a) Consolidation and updating of CAD menu.
    (b) AI introduction.

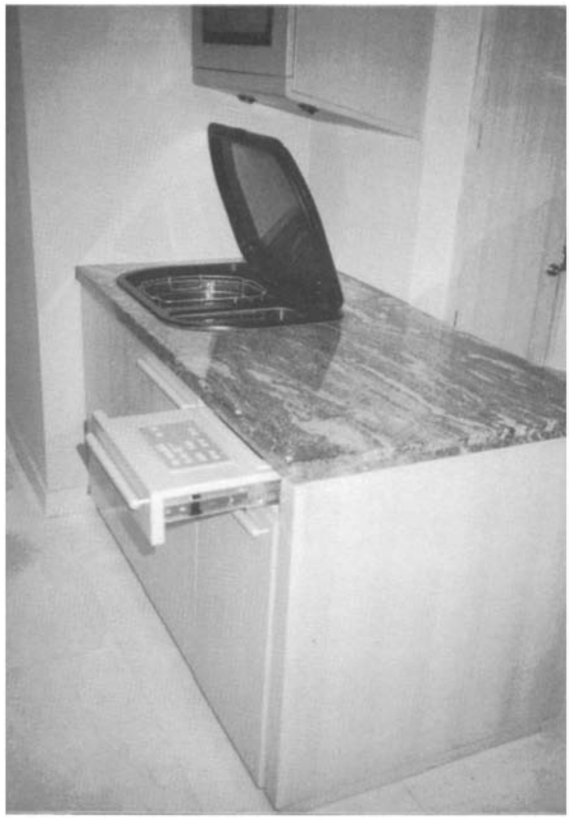

Figure 7.18 Fully automated dish-washing and waste-disposal systems.

(c) Automatic reinforcing bar fabrication system, heavy reinforcing bar placing robot, automatic reinforcement assembly crane, concrete distributor, structural steel erection robot, painting robot (for general exterior wall, cylindrical structure), high-rise-building exterior-wall-painting robot, block parts assembly robot, ceiling work robot (board cutting, illumination fixture attachment, down light attachment), demolition robot.

APPENDIX 7. B
ASSESSMENT OF TECHNOLOGIES LISTED IN APPENDIX 7.A

1. Harmony with surrounding environment, balance of urban and residential areas, appearance.
2.

   (a) Types of new material, e.g. multipurpose type having both lightness and strength, recyclable.
   (b) Effects of passive air conditioning, labour-saving devices, prevention dew condensation.
   (c) Natural energy self-sufficiency, survivability of housing (Japan has many energy resources: solar, geothermal, wind, hydro-electric).
   (d) Efficiency, labour-saving in relation to furniture.

3.

   (a) Degree of reduction in weight, high-strength properties (RC high-rise housing using high-strength concrete).

4.

   (a) Degree of use of underground and attic space, efficient layout of storage space.
   (b) Co-existence with conventional and technologies.

5.

Figure 7.19 Intelligent powder room.

Figure 7.20 Intelligent toilet, with health check functions.

(a) Whether or not effective in preventing spread of fire.
(b) Effectiveness of regional disaster prevention information supply system.
(c) Effectiveness of disaster prevention system in large-scale housing development, intelligent city.

6.

(a) Emergency activation.

Figure 7.21 A 1km high accommodation tower called Sky City 1000 (Takenaka Co. Ltd).

(b) Whether or not there is accurate liaison set-up.

7.

(a) Accuracy of computerized control of maintenance and administration.
(b) Efficiency of inspection automation.

8.

(a) Securing of functions in high-level information communication system and in intelligent city within region.
(b) Cost of home automation (HA system) (degree of cognizance of HA by housewives in general 40%, while on the other hand to hold down cost of HA will lead to great reductions in functions).
(c) Whether measures have been provided against congestion and computer trouble.

9.

(a) Relation between degree of dependence on outside services regarding household chores and degree of degradation of human nature and human spirit.

10.

(a) Relation between excessive securing of safety and degree of impairing of self-preservation capability (will not know to cushion fall with hands without experiencing injury from fall).
(b) Effectiveness of abnormality detection system for elderly and disabled persons.

11.

Figure 7.22 High level green area in Sky City 1000.

(a) Effect of uneven settlement prevention.

12. Miniaturization of bioreactor, efficiency.
13. Degree of completeness of CAD menu, whether conforming to concept of computer integrated construction, state of incorporation in system.
14.

(a) Nature of substitution for humans by robots (heavy labour and monotonous operations)
(b) Ease of handling of robots by elderly, females, disabled persons.

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8
Technologies for development

R.J.S.Spence

8.1
INTRODUCTION

The first chapter of this book by Michael Chisholm describes the demographic changes which will shape the demand for housing in the developing world into the next millennium. In the low-income countries, the processes of population growth and urbanization which they have been experiencing for the past 30 years are expected to continue at a gradually declining rate. Already, these processes have contributed to increasingly intolerable living conditions for many millions of the people of these countries in both urban and rural areas.

The first UN Global Report on Human Settlements of 1986 (UNCHS, 1987) offers the following bleak summary of the situation:

> There is little evidence in the majority of developing countries to suggest that…human settlements situations, in either urban or rural areas, are being impro ved. The picture that emerges is one of a challenge not being met and of governments losing ground in their efforts to meet it. When demographic and urbanisation trends are imposed on the present human settlements situation and the conditions which prevail in cities, towns and villages, the problems take on forms which threaten to become unmanageable.

Before examining future prospects it is essential, therefore, to take stock of the present situation and assess the contribution which technology can make to improving it. Some facts, by now well established (UNCHS, 1987) are:

1. between 1960 and 1990, the populations of the developing countries increased by 100% from 2 to 4 billion;
2. in 1960 less than 500 million people lived in towns and cities in the developing countries: this had increased by 1990 by 850 million, an increase of 170%;
3. in both urban and rural areas, unemployment and underemployment rates are very high;
4. where they have grown at all, rural incomes have grown much more slowly than urban incomes, the consequence of a huge disparity between the resources devoted to urban and rural development;
5. in many countries a majority of the population live in absolute poverty with insufficient income to provide for their basic needs—food, clean water, clothing and shelter; the proportion of the population in poverty in many countries is growing;
6. in many of the cities 40–50% of the inhabitants live in slums and ‘informal’, i.e. squatter settlements, in poorly sited housing of impermanent materials with almost no amenities, and in conditions of acute overcrowding—over 2 people per room is common;
7. in spite of considerable investment during the past decade, a high proportion of both rural and urban poor is still without access either to clean water supply or adequate sanitation;
8. biomass fuels obtained by exploitation of forests and animal dung are the major sources of energy for both rural and urban households, though in urban areas there is a shift to oil-based fuels; even where it is available, electricity is little used;
9. the impact of the huge concentrations of population on the natural environment—particularly the forests and water resources—is in many cases so great that it cannot be sustained, and present efforts at environmental protection are minimal;
10. the incidence and scale of natural disasters caused by inadequate housing is increasing.

Within these global indicators there are of course considerable local variations and there is welcome evidence that conditions in some of the largest Asian low-income countries are improving. But even in these countries the achievement of adequate living standards for today’s vast populations is a remote goal, without considering the addition of as many people again within the next 30 to 40 years. Given the scale of the need and the poverty of resources, it is not surprising that attempts by governments and international aid agencies to improve the situation by direct investment in housing and infrastructure have had little impact. Through the experience of the past 20 years it has already become apparent that state provision of housing, or even of serviced plots, is not affordable in most situations.

Yet it has also been shown that given certain basic conditions of employment and security of tenure, people over time invest in the improvement of their own homes and in the development of community services, and that such action can be stimulated by relatively small external investments of material aid and technical assistance. Consequently, there is now increasing acceptance that strategies for the improvement of human settlements should concentrate on making the conditions for self-help and mutual aid as favourable as possible. Such *enabling strategies* are based on actions in support of 'locally-determined, self-organised and self-managed settlement programmes' (UNCHS, 1987). Such programmes are clearly a challenge to conventional top-down approaches to settlement planning, but there is growing evidence that they work where the conventional approach cannot.

Choosing such strategies has a profound influence on the choice of technology to support them. Technologies are needed for shelter, for infrastructure, for transport and for domestic energy use which are also able to be locally determined, self-organized and self-managed. They will need to be cheap, operate at a small scale, make use of local resources of materials, labour and management, and yet provide living standards significantly higher than the technologies used by the poor today. They will need to be very different in nature from the current technologies of the industrialized world. Until now, it is imported versions of these technologies, or their products, which seem to be the only alternative to traditional labour-intensive technologies. The so-called *appropriate technologies* have yet to make a decisive breakthrough. To understand their potential and their limitations, we need to look briefly at the development of the concept of appropriate technology, and formulate some more precise ideas about appropriateness, before returning to look at some particular areas of technological promise and achievement.

8.2
APPROPRIATE TECHNOLOGY

The idea that small-scale low-capital technologies are needed to raise the living standards of the poor is not a new one. In India in the 1930s Gandhi called for 'production by the masses rather than mass production', and tried to establish self-reliance and independence from foreign industry as an essential basis for independence. The charka (village cotton spinning machine) became the symbol of the independence movement. Later, in the Second Plan period (1956–61) efforts were made to promote the village production of cloth and other basic goods as a village based labour-intensive alternative to large-scale mechanized industry: a quarter of a million improved 'ambar charka' spinning sets were made and put into production in the villages (Dandekar and Rath, 1971). China similarly promoted rural industrialization during the 'great leap forward' period, the best-known example being the backyard furnaces of which 2 million sprang into existence within a few months in 1958.

What both of these huge programmes failed to take into account was that the productivity of these basic technologies was extremely low and that the quality of what they produced was often not good enough for its intended use. Subsequent studies of the 'ambar charka' showed that the capital cost per unit of output of the village spinning sets was ten times higher than mechanized production, while the hourly unsubsidized earning of the workers was only one tenth that of urban workers. Most of the iron produced by the Chinese backyard furnaces was useless. Both programmes were abandoned, and subsequent efforts at rural industrialization in both countries learnt from them.

In the 1960s economist Fritz Schumacher in a series of studies in developing countries proposed the idea of 'intermediate technology'. For Schumacher, following Gandhi, the problem for developing countries was to create workplaces in the villages. He elaborated the task in four propositions (Schumacher, 1973):

1. workplaces have to be created in the areas where people are living now, and not primarily in the metropolitan areas into which they tend to migrate;
2. these workplaces must be, on average, cheap enough so that they can be created in large numbers without calling for an unobtainable level of capital formation and imports;
3. the production methods used must be relatively simple so that the demands for high skills are minimized not only in the production process itself but also in matters of organization, raw material supply, financing, marketing and so forth;
4. production should be mainly from local materials for local use.

These requirements, Schumacher argued, implied a regional approach to development, and an effort to develop an 'intermediate technology'. He recognized that the existing village technologies were insufficiently productive, and proposed that what was needed was a technology which enhanced productivity but at a cost per workplace much lower than that of the already industrialized countries, so that workers could over time afford to finance their own tools or workplaces.

To research, develop and promote such technologies, Schumacher in 1965 founded the Intermediate Technology Development Group, the first of many international and national organizations devoted to small-scale technologies for development. Technologies for housing, building materials and domestic energy use have generally been key areas of investigation because of their universal use and great local variety: and over the past 20 years a great range of non-industrial technologies has been developed and demonstrated by such organizations in the rural areas (and less commonly the cities) of the developing countries.

These include many technologies for the small-scale processing of local raw materials for use in building: the manufacture of bricks and tiles, lime and even cement on a village scale; the processing and use of local stone and soil as building materials; the treatment and processing of timber and other vegetable materials. They also include technologies for the low-cost assembly of these materials into homes and community facilities.

Development of small-scale energy technologies has been equally active. For energy supply, village-scale wind generators, hydropower plants, solar energy plants have been developed; for domestic energy use the emphasis has been on improved stoves for burning firewood and charcoal, solar energy devices, biogas plants.

All of these technologies and many others have been the subject of extensive laboratory investigation and field testing, and many of them have been taken up through aid and demonstration projects in a wide range of conditions. But to date only a few have become commercially successful on a wide scale away from the protective environment of the aid project. Of course the process of technological innovation is bound to result in many failures, and even for the few successful innovations, the time-lag between innovation and large-scale dissemination can be expected to take years. But the slowness of take-up of these technologies has other causes. Recent critics of project aid have argued that transfer of 'appropriate technologies' often fails because the donor agencies fail to match proposed technological interventions with the perceived needs of the intended beneficiaries.

Technical aid to the rural poor, according to Dudley (1991) will be successful to the extent that it fits with the existing processes of technological change of the poor communities themselves. To have the best chance of being adopted an innovation should be reasonable, recognizable and respectable. It should be reasonable in meeting a problem which the villagers have themselves identified, and it should demonstrably solve that problem. The innovation should be clearly identifiable, describable, and visible both to the villager and others. And its adoption should enhance the user's self-esteem, a notion which can often be identified with a wish to be seen as modern.

For Cabannes (1988), writing from the experience of urban upgrading projects, an appropriate technology is one which 'permits real control by the user of the production process, while considerably reducing the profit margins of intermediaries'.

These observations suggest that a new set of criteria needs to be added to the older predominently economic ideas about appropriateness. Indeed they suggest that some innovations which conflict with the strictly economic criteria may in fact be highly appropriate. For instance, in urban areas, the use of manual power tools may be a way of enabling communities to increase the productivity of voluntary labour. In rural areas the most successful innovations are often those which combine manufactured materials—glass, corrugated iron, plastic pipes—with houses of traditional form and materials. In particular, houses of the poor tend to acquire respectability—in the eyes of their owners and the local community—precisely because they are modern and incorporate visibly the products of the large-scale manufacturing sector. Conversely, innovations which appear too rural, or traditional, may be unsuccessful even though technically much superior: thus earth construction, even using high-quality stabilized soil blocks has never been considered respectable for use in urban areas, and this is not simply, as many suppose, a question of restrictive ('colonial') building regulations.

Thus local criteria and insights must play as great a part as general economic criteria (small-scale, capital saving) in determining which technologies are appropriate for a given task or programme. In the end appropriate technology is a pragmatic notion; to be appropriate a technological innovation must be shown to be successful, and replicable, in the intended context.

To date the extent of the investment in new and promising technologies for low-cost urban housing is extraordinarily limited, given the scale of the need and the scale of the building activity already in progress. What is needed is a huge increase in research and innovation in technologies of possible appropriateness to human settlements development. Some time ago Singer (1973) estimated that only 1% of the world's research and development effort took place in the developing countries. And even though we can expect that at least 90% of the dwellings constructed during the next 50 years will be constructed in the developing countries, that ratio is probably a good estimate of the relative efforts devoted to building research today.

To understand where and how that research and development effort might be directed, we look briefly at three key areas: building materials, domestic energy use and disaster protection and also consider diffusion through builder training. The scope of the paper does not permit discussion of other important technologies such as water supply and sanitation or roads and transportation, equally important to the future of human settlements.

8.3
BUILDING MATERIALS

Every UN report on housing in the low-income countries identifies short-ages and high prices of building materials as crucial constraints to improving housing conditions. At first sight this is surprising given that all countries have a variety of raw materials—earth, stone, limestone, timber and other vegetable materials—and their own traditions of processing them. But the use of these traditional materials is rapidly declining. Pressure on the land from increasing population and deforestation has drastically reduced the availability of trees, plants and animal products which once offered free building materials for the rural areas. Timber for roofing, doors, furniture, grass or palm leaves for thatch, animal dung for flooring and plastering are all in short supply because of growing demand, shrinking woodlands and competing other uses such as for fuel or industrial use, and as a result they have become cash commodities. But the manufactured materials which are tending to replace them are produced in large-scale factories using imported technology and have high energy costs: these have been rising in price in recent years much more rapidly than wages.

These circumstances provide the stimulus for the development and introduction of intermediate technologies for building materials production: technologies which make little use of factory equipment or imported materials, but are based on local resources and skills, and have the potential to be self-replicating in relatively poor communities. In practice partly for reasons mentioned earlier many of these technologies have so far made little impact, and remain at the R&D stage, and much of today's urban development at the lower income levels is taking place using impermanent materials or recycled materials from industry. But two important new small-scale technologies have become firmly established in the past 10 years: fibre concrete roofing and small-scale cement production. Examining how this has occurred gives some useful clues to the nature of 'appropriateness'.

Fibre-concrete tiles are made from a mixture of a sand-cement mortar with natural fibres enabling it to be cast into a thin sheet. A process for making them on a small scale was originally devised by a British entrepreneur John Parry in the mid -1970s, with the intention of creating a new appropriate roofing technology for developing countries. The material was tested in a whole range of building projects worldwide during the early 1980s. This resulted in numerous technical improvements both to the product and the process, and to the development of many competing processes developed locally. It was shown that in many situations the tiles are substantially cheaper than alternatives of comparable quality (such as clay tiles), and demand for the tile-making kits began to grow (Parry, 1985). There are now over $2.5\times10m^2$ of fibre concrete roofing installed worldwide, mostly made with the tile-kits imported from the UK. These consist of a vibrating table and a set of moulds and other accessories sufficient for production at scales ranging from 100 to 400 tiles per day. The vibrator is powered by a 6V car battery with a mains or hand-powered option. At a cost between £1000 and £2000 per workstation (which can also produce other concrete products), the technology is a good investment for the small-scale urban entrepreneur in low-income countries. But even to obtain this much foreign exchange is often impossible, and local innovation and manufacture is beginning to replace imports in several East African countries where the technology has been demonstrated through aid projects: both the small scale and technical simplicity of the process are encouragements to local innovation. (See Fig. 8.1.)

Cement is a crucial material in all building work. In the industrialized countries it is manufactured in very large-scale production units which offer economies of scale, and many developing countries have obtained cement by importing either the material, or the complete production process, from the industrialized countries. Indian technologists have been experimenting with mini-cement plants since the 1960s in an attempt to develop a process for producing cement of identical quality, but using equipment at a scale which can be made, managed, and owned locally without the involvement of transnational capital. The breakthrough took place in the early 1980s, with some tax incentives from the government spurring development efforts. A particularly successful technology is the Saboo system, based on kilns producing 20–30 tonnes per day. Unlike the large-scale plants, which are based on rotary kilns which are uneconomic at scales below about 2000 tonnes per day, the mini cement plants use a vertical shaft kiln which can operate economically at this very small scale. Although unit production costs in these small plants are slightly higher than in the large-scale plants, this is more than made up for by the reduction in distribution and other costs (Sinha, 1990). Today there are around 100 mini cement plants producing or being built, and already around 10% of India's cement is produced in them (Sinha, 1990), a proportion which is growing rapidly.

In each of these cases, private interests have taken the lead in developing new and successful production processes. But in each case they have been assisted by NGOs and appropriate technology organizations and to some extent by governments in promotion and dissemination of the product. The same partnership is even more crucial in the field of energy conservation.

8.4
HOUSEHOLD ENERGY CONSERVATION

Household energy is important because it accounts for a very high proportion (50–90%) of national energy consumption in most of the low-income countries, and because it is mainly supplied by biomass fuels which are rapidly becoming scarce. In

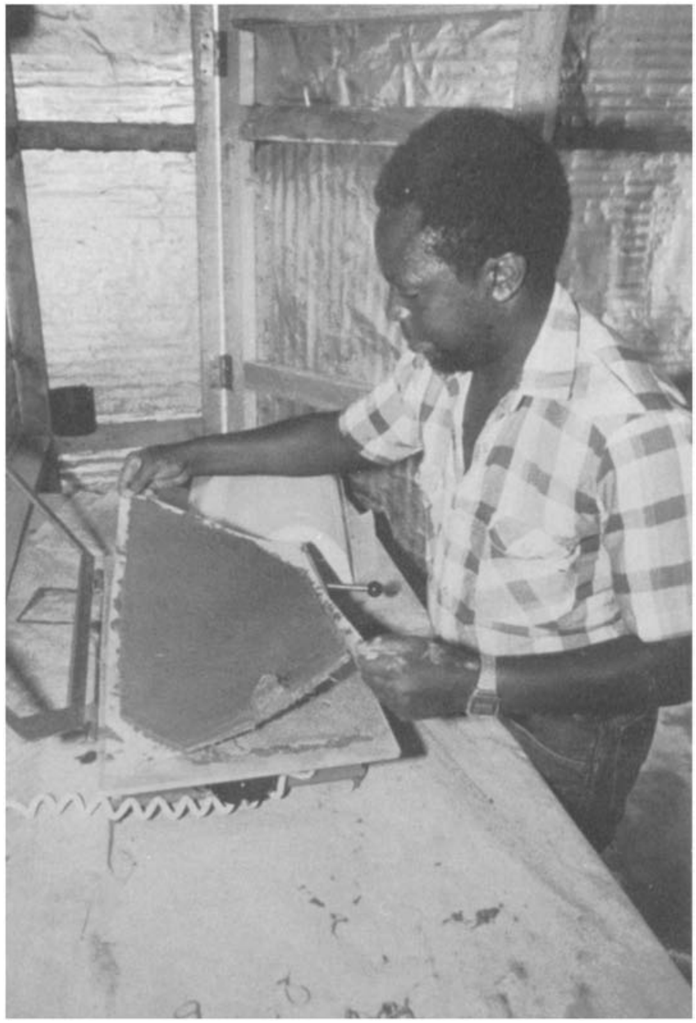

Figure 8.1 Manual fibre-concrete tile-making using the Parry process (from ITDG).

rural areas the proportion of household energy which is contributed by biomass fuels varies from 50–60% in Latin American countries, to 80–90% in Asia, and over 90% in most of sub-Saharan Africa. Although the proportion of biomass fuels used in urban areas is smaller, with an increasing use of kerosene, LPG and electricity, the urban poor still depend almost exclusively on biomass fuels, while use of modern fuels is limited to middle and upper income levels (Leach, 1988).

The connection between fuelwood use and deforestation in general is not a clear one, because traditional rural use of fuelwood tends not to be associated with tree-felling. Thus there is no certainty that reduction in fuelwood consumption would arrest deforestation, except where heavy use of charcoal is made in urban areas. Nevertheless deforestation for extension of agricultural land and logging is causing a rapid dwindling of woodfuel resources in many areas leading to rising costs—either in cash or in time devoted to fuel-gathering—for the poorest households. Substitution of fossil fuels for biomass is generally not an option either nationally, because of the energy imports this would entail (Qazi, 1989), or at a household level, because of the investment costs of the equipment needed.

One hopeful strategy is the use of improved technology for wood and charcoal cooking stoves to reduce woodfuel consumption. Cooking accounts for by far the largest part of the fuel use of poor families worldwide, yet the stoves commonly used often have fuel conversion efficiencies (from fuel to in-the-pot energy) less than 10%. Increasing fuel efficiency of cookstoves, even by a small amount, could therefore have a significant effect on household budgets; and improved cookstoves can have other benefits too, such as reduction of health risks from smoke, reducing cooking time, and creating employment opportunities in small industries (Joseph, 1989).

Over the past decade, numerous government agencies and NGOs from developing countries have become involved in programmes for the design, promotion and dissemination of improved stoves. In 1983 a new association, the Foundation for Woodstove Dissemination (FWD), came into being, and a conference in Guatemala in 1987 heard reports from 20 different countries on progress (Caceres, 1989). Statistically, the achievements are impressive: 180000 stoves produced in Kenya, another 180000 in Karnataka, South India; over 3 million in India as a whole; 55 million in China. Some of the larger

Figure 8.2 The Kenya Ceramic Jiko: made and sold in the Nairobi informal market. Traditional jiko in the background.

programmes are run by government ministries and involve substantial subsidies; some of the smaller ones were started by local NGOs with very limited funding, and have aimed at a stove design which would be affordable by poor families without subsidy.

One of the most interesting examples is the Kenya Ceramic Jiko, a charcoal-burning stove aimed at the urban market in Kenya, where charcoal prices have been increasing rapidly, but alternative fuels are unavailable. The design, testing and dissemination of this stove were done by an NGO, KENGO, with limited grant aid from USAID, starting in 1982. The design was based on a Thai stove design, but adapted both to the cooking needs of urban Kenya, and to the skills of the existing informal-sector stove producers and small-scale industry. It consists of a steel cladding made from waste chemical drums, and a ceramic liner, the principal improvement over the traditional stove. An extensive testing programme and design modifications followed the initial design, followed by a training programme for metal-working artisans and pottery makers. The result was a stove which could be sold for around $4–6, more than double the cost of the traditional stove, but with a fuel consumption of 40–50% less, and which would consequently pay for itself in four weeks in reduced fuel costs. An intensive dissemination period followed, using mainly the markets and trade fairs where jikos are normally made and sold. The success of the new jiko was immediate and spectacular (Harrison, 1987). By the time of the 1987 FWD meeting over 180000 had been sold, and the traditional jiko had become hard to sell. Stove producers were also increasing their incomes, and 30 enterprises were employing 98 artisans. The use of the stove was spreading to towns outside Nairobi and to the rural areas too. (See Fig. 8.2.)

Improved woodstoves are not the one answer to declining firewood supplies. There are many others, ranging in scale from firewood plantations to changing cooking habits. In China, for example there are claimed to be over 5 million biogas plants in operation which produce methane gas from night-soil and domestic refuse in sufficient quantity for household cooking needs (Zhao Xihui, 1988).

8.5
DISASTER PROTECTION

There is increasing evidence that urbanization and intensification of land-use in the poorer countries is increasing the vulnerability to disasters of both urban and rural settlements. In the past two years alone earthquakes in Peru, Iran and the Philippines, high winds in the Caribbean and floods in Bangladesh and Sudan have resulted in large death tolls and the destruction of millions of homes. These are the large headline-grabbing disasters. Minor unreported tragedies—homes swept away by landslides, flash-floods, windstorms and fire—occur daily. The basic cause of these disasters is the same. Through poverty, people are forced to occupy land which is vulnerable to disasters and to build their homes using cheap impermanent materials which offer no protection from the natural hazards they face. In the rural areas the loss of the forests means that the traditional methods of building, which incorporated some disaster protection, are no longer possible. In the towns, even when modern building technologies such as reinforced concrete or steel frames are used, they are often applied with an inadequate understanding of the likely behaviour in a disaster, and this can make them lethal. As the Mexico City and Iran earthquakes and the Jamaica hurricanes have shown, reinforced concrete frames with inadequate reinforcement or badly made concrete will collapse catastrophically, steel roof sheets may be ripped off and blow dangerously about. The skills needed to design and build safely with these materials are often missing.

Programmes for improving human settlements worldwide thus need to incorporate means to reduce their disaster vulnerability at an affordable cost and using mainly local resources. A mixture of both structural and non-structural measures is needed. Structural measures may include the construction of community defences from flooding or mudslides as in the Rimac Valley in Peru (Maskrey, 1989); or they may include the incorporation of low-cost bracing or roof fixing into low-cost houses as in Jamaica as a protection from wind damage (Hodges, 1990); or the addition of timber lacings into other-wise highly vulnerable stone masonry walls for earthquake protection as in Eastern Turkey (Spence and Coburn, 1987). Non-structural measures may include relocation of particularly vulnerable communities; public awareness programmes; and evaluation of alternative mitigation strategies.

A difficulty in the implementation of disaster mitigation strategies is to convince the participants and public authorities that their investment will be worthwhile. Unlike the investment in a new woodstove, which has a certain payback period of four weeks, the payback period for disaster protection building modifications is highly uncertain. The disastrous event may recur in one year or maybe not for 10 years or more; the level of protection used may be adequate for the most recent event, but the next may be more severe. The cost of incorporating protection may be quite large, but the consequences of inaction can be total destruction of property or loss of life. Risk studies can help identify the possible long-term costs and benefits of disaster-protection programmes, and show the cost-effectiveness of alternative strategies.

In a joint project with the Government of Turkey, the Martin Centre of Cambridge University looked at the implications of a range of alternative upgrading strategies for the stone masonry houses typical of Eastern Anatolia which have been particularly vulnerable to the earthquakes which are common in the region. The study involved investigating local building traditions and also the testing of some full-scale buildings on a locally built impulse table (Spence and Coburn, 1987). (See Fig. 8.3.)

Figure 8.3 Testing full-size strengthened stone masonry houses on the Ankara impulse table (from Andrew Coburn).

The results were surprising. It was shown that a programme of incorporat ing timber lacings (a tradition in some areas) into the stone masonry walls of new all rural buildings would cost less over a period of 25 years than the amount which would be saved in reconstruction costs in the earthquakes which could be expected to occur over that period of time. And it would also save about 3000 lives. The Turkish Government is beginning to re-direct its disaster protection efforts towards strengthening houses of the traditional construction rather than replacing them with modern building types.

8.6 BUILDER TRAINING

For low-cost disaster mitigation or building upgrading strategies to be effective, the dissemination of knowledge of improved techniques to local builders and artisans is crucial. In poorer communities individual families play a large part in the provision of their own shelter. In the past, local re-sources were often adequate, and traditional techniques of building could create acceptable levels of comfort and security. The local builders would act as experts, passing on the accumulated experience of local building methods and giving assistance to the families. In many areas this pattern persists. According to Norton (1989):

> The common relationship on domestic building sites in developing countries remains that of the local builder working with one or two apprentices and the support of the family for whom the house is being built, who provide the unskilled labour.

The growing population, new building needs such as schools and clinics, changes in availability of materials and the process of urbanization have all increased the need for skilled builders, but the traditional skills are no longer adequate. In parallel with the need for technical innovations to respond to these changes, there is a need to train the local builders to disseminate appropriate innovations. Indeed the local artisans are the people best equipped, from their knowledge of the local resources and of the culture and economy of the area, to decide which of a range of possible innovations is likely to be successful.

In recent years builder training has become a key activity for building professionals who want to contribute to housing improvement in the poor countries, but recognize that their training (often as building designers) qualifies them to contribute only to housing for well-funded agencies or the wealthy.

The aftermath of a disaster often provides an opening for such training, since there is a strong demand for rebuilding to incorporate improved techniques. As part of a reconstruction programme following a major typhoon in Vietnam a small international NGO Development Workshop (Norton *et al.,* 1990) joined with the regional government in a training programme aimed at improving standards of construction for small buildings. Short builder training workshops of 2–3 weeks were held in the major towns; the participants in each course were given the task of designing and building a new public building using local materials both to develop their own skills and as a demonstration for local people of improved techniques. (See Fig. 8.4.)

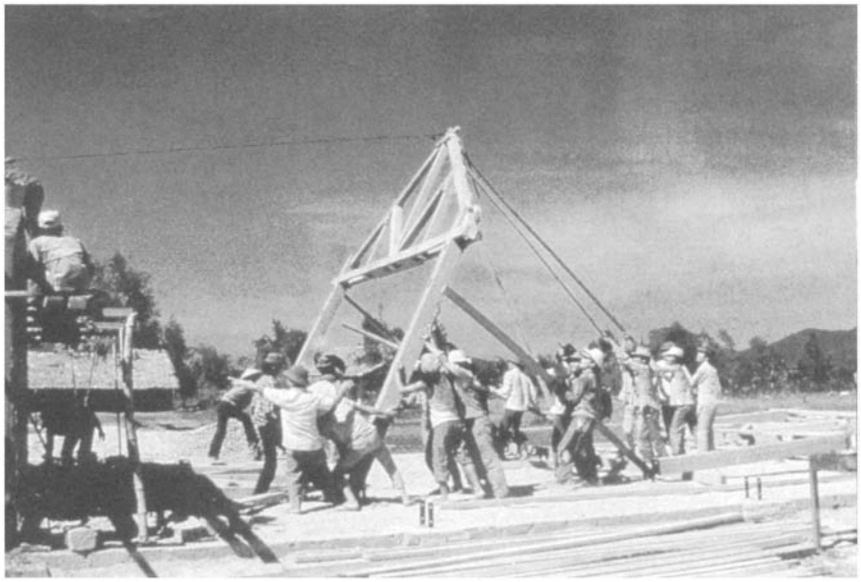

Figure 8.4 Builder training programme in Vietnam: participants raise the main roof frames for the first demonstration building, a primary school (from John Norton).

After the 1982 earthquake in Yemen which destroyed 25000 buildings in a region of 6000km^2, OXFAM funded the Dhamar Builder Education Project, which over three years conducted a training programme for the artisan builders of the region. The purpose of the courses was to improve the quality of the housing stock by introducing good practice techniques, including techniques to improve earthquake-resistance of the local stone masonry, at a time of extensive rebuilding. A subsequent evaluation (Coburn and Leslie, 1985) followed up the trainees: it found that the programme had reached 25% of all small builders in the area, and most were incorporating the techniques taught into their work.

Ecological pressures can present another opportunity for builder training. In Niger Development Workshop has for nine years been helping to teach techniques of mud-vaulting (following the work of Hassan Fathy in Egypt) to builders no longer able to use the disappearing vegetation of the region for roofing (Norton, 1990a). In Kerala in South India, architect Laurie Baker (Spence, 1980) has devised and popularized low cost durable alternatives to increasingly expensive thatch or concrete frame construction, by means of builder training.

Active involvement in training and dissemination and responsiveness both to local conditions and to the knowledge and skills of the local artisans are essential to the spread of appropriate technology. But the result of such training programmes is something much richer: the emergence of a new regional architecture which draws on local climate and materials, recognizes people's aspirations for a better life, but (unlike the low-cost buildings proposed by so many official schemes) is accessible to a large majority of the population.

8.7 CONCLUSION

To achieve tolerable but sustainable living conditions for a global population of 10 billion people within the next century is a formidable challenge. It will involve many changes in our current attitudes to the process of housing creation, and not least a radical change in housing technology. The essential task is to find ways to provide more with fewer material inputs, but making greater use of people's own energies and skills. Peoples' expectations of space, privacy, comfort, convenience and energy availability will continue to increase. Meanwhile, the resources available for conversion into these amenities are static or declining. Currently available manufacturing and energy technologies are beyond the reach of most people in the poor countries.

But there is tremendous scope for technological innovation in utilizing the resources which are available to people to make the goods they need more efficiently—reducing energy wastage, improving performance and durability—and using their own skills and organizing ability. And there is growing evidence, some of which has been presented here, of an upsurge of technological innovation of this type within the poor countries themselves. It is possible to see the programmes described above, improved stove programmes, fibre-concrete tiles, disaster protection schemes, and so on not as isolated incidents of barefoot engineering at the margins of technological progress, but as the beginnings of a worldwide revolution in housing technology, even as the forefront of technical progress itself. These are the technologies of enablement.

There is now enough experience for their characteristics to be identified. Six features seem to be common.

1. They respond to pressing individual or family needs rather than broader concerns such as ‘the environment’.
2. They utilize and build on existing local skills and traditions.
3. They are small enough in scale to be designed, made and managed with local resources.
4. They are relatively simple in technical concept, but complex in their fit with the local context.
5. Local small manufacturing enterprises and artisans are the driving force for innovation and diffusion, but they receive strong backing from concerned NGOs and government agencies.
6. They create savings for individual households for a low initial cash cost.

It is worth asking, in conclusion, whether there is a contribution which science and technology in the already industrialized countries can make to these enabling technologies. The best way for industry to contribute would be by assisting research and development in appropriate technologies rather than looking for export markets for its current products and processes. Likewise, there is an enormous part which could be played by our aid programmes if they were directed to support the indigenous process of technological innovation in the poorest countries, rather than tied to imports from the donor country. And there is certainly a big role for individual professionals—engineers, architects, scientists—in helping this process along if they are willing to become committed to action at the local level. Most of the programmes described above have had some involvement from individuals from the developed countries and will continue to benefit from it. This involvement has been and can be assisted by those academic, research and professional institutions which are prepared to support the long term and sometimes fruitless efforts in the field which are required. There is much still to do in widening the range of options available for the poor, and the industrialized countries potentially have an important contribution to make in this task.

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9
Barriers to effecting change in housing

J.P.Eberhard

9.1
THE NEED FOR CHANGE IN NATIONAL BUILDING RESEARCH AGENDAS

The building research agendas of the developed nations of the world have changed little since before World War II. These agendas were largely established by physicists, chemists, and civil and mechanical engineers who could frame questions and organize experiments within the general ground rules of the dominant physical science models. The resulting research projects were politically safe both within the national laboratories where they were organizationally located, and within the larger context of the design and construction industry of each country. The managers of the national research programmes were comfortable with the scientific methods used, the credentials of the research staff, and the nature of the publications produced. The outcome was good solid material closer to the applied end of the spectrum than the more fundamental research conducted by other organizational units of the national science programme, but not so speculative or so 'soft' that members of the Royal Society or the National Academy of Sciences would raise serious questions.

When the managers of these programmes were required to appear periodically before legislative bodies for the financial resources needed to support their enterprise, they could do so with the assurance that they would have the support of the scientific community, and would seldom have any opposition raised by the politically active arms of building industry organizations. Mostly this research provided, and still provides, good solid numbers for codes and standards-making processes or for engineering design hand-books. It creates little or no threat to the established market patterns of building materials and equipment producers because policy questions are not raised about responsiveness to consumer requirements or economic change.

To deal with questions of barriers to or incentives for such research is to deal with marginal issues. It is as though the medical world limited research to measuring the impact of silicon fibres on the structure of microscopes, rather than exploring the fundamental causes of disease by using microscopes. Or, suppose that the agricultural research community limited research to trace elements in fertilizers to higher crop yields. Such building research causes no harm, but no major reform is likely to emerge that would change the products or processes of the housing industry, or lead to land reform, changes in legal or regulatory actions, or new financial mechanisms. The housing industry in Western society prefers the status quo and will not support government research programmes that might upset the 'delicate balance' of the housing markets.

This way of organizing research in national building laboratories was effectively transferred to those programmes established in Third World countries during the past 40 years. The same research agendas are repeated over and over again, with much the same results. The managers of the laboratories in developing countries can point with pride to their cement and concrete testing programmes that use the same equipment and same methods already published in the literature, or they can show how they have progressed to the point of using small computers to calculate thermal properties of various native materials, or they will show visitors their laboratory in which they can calibrate the flow of water in cast iron pipes of various diameters. Outside these same research laboratories, often within view of visitors, are the shanties and squatter settlements in which the majority of the population of their countries live. The work going on inside their laboratories is essentially unable to make any impact on the intransigent housing problems of their populations. Is it any wonder that the managers of these building research laboratories are constantly complaining that their government will not provide them with adequate funds for their programmes?

Changing the agenda of research in national building research programmes is unlikely to happen without a shift in the political support needed to give housing issues high priority. First the fundamental 'right' of all citizens to decent housing and a fit environment has to be accepted by the majority of citizens and converted into political support. I present here a case for making changes in the national housing priorities of Western societies, argue that housing issues are interwoven with the issues of community infrastructure, and propose a possible reformulation of housing research based on such changes and realities. The barriers to effective technological solutions or design changes in housing are primarily questions of political will, not the classic roadblocks of uniform building regulations, restrictive labour practices, and under-educated design professionals.

> Industrial technology does not grow out of a self-contained logic of scientific or technical necessity: which technologies develop and which languish depend crucially on the structure of the markets for the technologies' products; and the structure of the markets depends on such fundamentally political circumstances as rights to property and the distribution of wealth.
> (Piore and Sabel, 1984)

9.2 RESEARCH CONDUCTED IN NATIONAL LABORATORIES

The research thrust of national research laboratories in the different economic sectors of the world is close to uniform. The primary work of a cross section of these laboratories is described as follows (excerpted from a report for the Building Research Board of the National Research Council (BRB, 1989)).

9.2.1 Canada: Institute for Research in Construction, National Research Council of Canada

Performs research in fire performance, building materials, services, and structures; geotechnical engineering; noise and vibration; codes and standards; information systems; provides testing services through contract research; performs advisory services; undertakes technology transf er activities.

9.2.2 UK: Building Research Establisment (BRE)

Performs research in civil engineering, geotechnical engineering, construction, fire protection, building regulations, energy conservation, thermal engineering, acoustics, lighting, building services, materials, concrete and information systems.

9.2.3 USA Center for Building Technology (CBT)

Performs research through three divisions—Structures, Building Environment, and Building Materials—including analytical, laboratory, and field research in areas of engineering and science pertinent to the usefulness, safety, and economy of buildings. (Recently merged with Center for Fire Research of NIST.)

9.2.4 Hungary: Hungarian Institute for Building Science

Performs research in structural engineering, building physics, innovative construction methods and techniques, mechanization of building construction and automation, and building diagnostics.

9.2.5 Poland: Building Research Institute

Performs research in structural engineering, construction technologies, fire engineering, building materials, protection of building objects, physics and acoustics, finishing techniques, geotechnics, and building objects in mining areas.

9.2.6 GDR (pre-unification): Academy of Building of the German Democratic Republic

Provides research, development, planning, design, and consulting in architecture, civil engineering, and building construction through its 12 institutes: Town Planning and Architecture: Housing and Related Buildings; Industrial Buildings, Agricultural Buildings; Civil Engineering; Technology and Mechanization; Design and Standardization; Heating, Ventilating, and Structural Theory; Building Materials; Economics; Building Information Center; and Experimental Projects Division.

9.2.7
USSR: Central Research Institute for Building Structures

Perf forms research on civil and seismic engineering, computing, test methods, and fire protection.

9.2.8
Italy: Building and Civil Engineering Tests and Research Institute

Performs work in civil engineering and building technology, provides testing services, standards for materials and components, and conducts courses and seminars.

9.2.9
Belgium: Belgian Building Research Center

Performs research on building construction, civil engineering, building performance, energy conservation, and environmental issues; provides technical assistance to contractors and manufacturers; and conducts training and seminars.

9.2.10
France: Scientific and Technical Research Center (CSTB)

Performs research and testing in construction technology, building equipment, heating—ventilation—air-conditioning (HVAC), acoustics, fire safety, economics, architectural research, structural loads, and robotics.

9.2.11
Japan: Building Research Institute (BRI)

Performs research in disaster mitigation, structural engineering, materials, energy conservation and energy utilization, housing and building economy, fire engineering, environmental design, and testing and evaluation.

9.2.12
FRG (pre-unification): Institute of Building Research (IFB)

Performs research in physics and construction, techniques and experimental construction, and planning and productivity.

9.2.13
Denmark: Danish Building Research Institute (SBI)

Provides research in areas such as acoustics, building physics, structural engineering, building and environmental design, urban and regional planning, and building economics, and has an acoustics testing laboratory.

9.2.14
Sweden: National Swedish Institute for Building Research (SIB)

Performs research on energy conservation, materials, building climatology, water supply and drainage, building technology, housing, production, construction, land use policies, economics, information systems, and building planning.

The range of research in the world's building laboratories covers a comparatively narrow spectrum. Agendas are dominated by the physical and chemical sciences, civil engineering, and construction management. In a few cases, studies in building economics, planning or architectural research are conducted. But, the total sum of the research results produced by all of the building research centres of the world, including those in developing countries, has made only a marginal contribution to solving the world's housing problems. In 40 years, since the end of World War II, the core body of building knowledge may have increased by 10%. Research continues into how much trace elements strengthen concrete, how best to measure the thermal transfer rate through various materials, how failures occur in masonry walls, and the acoustic properties of various materials. Every laboratory has a structural testing facility, and every laboratory is still trying to improve the decimal accuracy of measurements.

While the world's construction laboratories have been working at the same narrow subjects for decades, all the while bemoaning their meagre budgets, research in other areas has been highly productive:

1. the capacity of computers has doubled every 10 years, while the price of computations has been reduced by 50% in each decade;
2. medical research teams around the world have essentially eradicated smallpox from the face of the Earth;
3. the legal profession has made civil rights an established fact in much of the world;
4. the biological sciences are on the verge of truly revolutionary new developments in genetic engineering;
5. the development of photonics has made possible fibre optic systems capable of providing communications capacity for telephone conversations between every person on the Earth in a fibre the diameter of pencil;
6. harnessing of nuclear power for peaceful uses has changed the potential for electrical energy across the world.

To change the focus of housing research and make an impact on human shelter systems, a new way of problem formulation, based on a new paradigm of housing rights, is required.

If the paradigm of housing based on citizen's rights becomes a reality, the world's research laboratories will need to change their dynamics from the present narrow focus.

9.3 HOUSING ISSUES IN WESTERN SOCIETY

The world invests about $1430 billion every year in the construction of housing, other buildings, civil works and utilities, or a little more than 10% of the world's Gross Domestic Product. Construction is the largest industry in the world. However, the volume of construction is not evenly distributed by population (see Table 9.1).

The volume of housing constructed varies from nation to nation but is approximately proportionate. The U.S. annual domestic construction volume of $330–390 billion is about 25% of the worldwide total. Of this total the US spends about $160 billion on housing.

In the US, housing problems continue unabated. A recent article in a prominent publication describes a set of factors that supports the need for a total re-examination of the housing question.

Table 9.1 Annual volume of construction (expressed in millions of US$ per year)

Sectors of world	*Number of nations*	*Constructed volume*
The low-income economies	35	25216
Middle-income economies	41	31857
Upper-middle-income economies	20	90259
East European non-market	8	264309
High-income oil exporters	5	23919
Industrial market economies	19	996887

9.3.1 Americans are moving towards a two-class system

> Most Americans no longer live in traditional communities. They live in suburban subdivisions bordered by highways and sprinkled with shopping malls, or in tony condominiums and residential clusters, or in ramshackle apartment buildings and housing projects. …And most people pack up and move to a different neighborhood every five years or so.
>
> Last year, the top fifth of working Americans took home more money than the other four-fifths put together. … the highest earners now inhabit a different economy from other Americans. The new elite is linked by jet, modem, fax, satellite and fiber-optic cable to the great commercial and recreational centers of the world, but it is not particularly connected to the rest of the nation.
>
> The stark political challenge in the decades ahead will be to reaffirm that, even though America is no longer a separate and distinct economy, it is still a society whose members have a binding obligation to one another.
>
> (Reich, 1991)

9.3.2
Today's concepts of household and private property are incongruent

> Private property is an institution which is apt to establish itself in societies in which the single family or household is the normal unit of economic activity, and in such a society it is probably the most satisfactory system for governing the distribution of material wealth. But the natural unit of economic activity is now no longer the single family, the single village or the single national state, but the entire living generation of mankind. (Toynbee, 1946)

In the United States, a dramatic shift in the composition of households has occurred in the past 30 years. In 1960 45% of households were married couples with children (supporting the World War II paradigm). However, in 1990, the number has dropped to 27%. While the number of households consisting of married couples only, with no children, has remained around 30% those classified as 'women alone', 'men alone' and 'other non-family' has more than doubled, from 14% in 1960 to 28% in 1990 (see Table 9.2).

There is a distinction between the concept of 'home' as a place in which one's domestic affections are centred and the concept of 'house' which connotes shelter. Simply building more houses does not provide more homes. The goal of any civilized society should be to provide 'homes' for every individual and citizen. It follows that making more houses available for prospective purchasers will not in and of itself accomplish that purpose no matter how dearly the mortgage banking community would like to convince us all.

Table 9.2 Composition of US households (from the 1990 US Census)

Household description	*1960*	*1970*	*1980*	*1988–90*
Married couples with children	44.2	40.3	30.9	27
Married couples no children	30.3	30.3	29.9	29.9
Other families	10. K8	10.6	12.9	14.6
Men living alone	4.3	5.6	8.6	9.7
Women living alone	8.7	11.5	14	14.4
Other non-families	1.7	1.7	3.6	4.4

9.3.3
The cost of housing and land is rising rapidly

In the Washington, D.C., area of the United States the cost of land in the central business district is now about $170 per square foot of buildable surface (this results in office building costs of about $400–470 per square foot). In London the equivalent land costs $1700 per square foot (or 10 times what it is in Washington). However, in Tokyo the equivalent land costs $8200 per square foot, with some areas being as much as $25000 per square foot. Land prices like these provide no possibility of being locations for housing, unless radical land reform or massive recessions were to occur.

In January 1988, a national magazine could report that from the summer of 1986 to the summer of 1987 the median house price in the northeastern United States jumped 37%, or $38600, to match the price of housing in Los Angeles. New home prices (and be clear that it is the *price* of houses not the *costs* that were escalating) jumped some $60000 from 1955. The speculative price of land was the major factor contributing to these increases.

9.3.4
Random reported problems of housing

There has been a reduction of housing starts in Britain from 222000 in 1988 to only 133 000 in 1990.

By 1990 there were 300000 residential loans in foreclosure in the US nationwide and 1.7 million delinquent loans. The boom in housing speculation was clearly at an end.

By November 1990, Thomas Fisher, the editor of Progressive Architecture magazine, would say that there are just too many people who are inadequately housed to argue that the home building industry provides what people want. He insisted that the free market could not meet everyone's housing needs, and that there were clear reasons to be doubtful whether the home building industry, free of obstacles, could meet all of the nation's housing needs on its own. He concluded by saying, In trying to solve our housing problems, we should not forget that Adam Smith was, as much as Karl Marx, a maker of myth.'

Now that the saving and loan industry in the U.S. has created a national disgrace by its greed, the Government, in an effort to sell off the delinquent loans with which the tax-payers have been stuck, has been giving away 2000 to 3000 houses as inducements to buyers of bank assets.

9.4 CHANGING THE PARADIGM OF HOUSING ISSUES IN WESTERN SOCIETY

Younger people, especially those with modest incomes, are increasingly aware that something is wrong with the way housing policy is formulated in the United States. The central theme of housing policy for at least 45 years has been that everyone should have an opportunity to buy a house that would become owned property. And, ownership carries with it the 'property right' of buying at one price and selling at another with the anticipation of a profit. For many Americans at or near retirement age, this appreciation in the value of houses constitutes the largest share of individual 'estates'. However, an increasing number of households are unable to buy into this form of speculative investment to obtain housing. For these households, home ownership is a myth and beyond reach.

Few would argue against the fundamental 'right' of a decent place to live and a fitting environment for all. Housing legislation always begins with a phrase to that effect, but, in reality, the bulk of the legislation is designed to protect the mortgage banking community's investments. The inadequacy of past performance with regard to this fundamental right makes it worth examining what form this right make take. In historical discussions of rights,
two types of rights are generally recognized.

1. *Alienable* rights which are transferable, as when the ownership of a car that has been sold is transferred to the new owner. Houses, in the US are generally tied to this form of right.
2. *Inalienable* rights which cannot be taken or assumed by another. They include 'life, liberty and the pursuit of happiness'.

The extent to which inalienable rights include 'a place to live', food, clothing and education is unresolved. Clearly the laws, customs, and beliefs of each generation of citizens of each country are modified to reflect current standards. But, the larger basic question of inalienable rights receives scant attention. It took more than 100 years for the slaves in America to be recognized as having inalienable rights identical to those of their masters. At issue was the definition of a citizen. The constitutions of most countries subscribe to a version of these rights for all citizens, as did the American Constitution of 1776. Slaves were included in the definition of citizen, and thus were entitled to inalienable rights of citizenship, but they were treated as private property by the law until after our Civil War.

The right to a 'decent place' to live and a community which provides a 'fit environment' is an *implied contract* between each citizen and the government. It need not be an alienable right that runs with the property. It belongs to the citizen not the artefact. It is not really an inalienable right either, at least not in the same intangible sense as life, liberty and the pursuit of happiness. In civilized societies there is an implied contract between citizens and government covering food, clothing and shelter. How this contract is fulfilled has a long history. Clearly for there to be homeless persons living on the streets in America is a contractual failure.

When governments attempt to meet their responsibilities under this implied contract for housing they have implemented it by various methods (depending on the country).

1. Using the invisible hand of the market place undergirded by the laws of real property. Such a policy may be 'efficient' (the skilful use of industry to accomplish desired results with little waste of effort), but it is often not 'effective' (adequate to accomplish the purposes of the implied contract) for every citizen.
2. Having the state provide living units by using the collective resources of society and distributing the right to occupancy by a mechanism other than purchasing (and the consequent ownership of real property).
3. Allowing families, in a simple society, the privilege of using a portion of the community's property on which to erect, with their own hands, a dwelling unit. In some countries there are now families who have taken a site for this purpose without having been granted the privilege by a government (e.g. the 'squatters' of Brazil).
4. Maintaining ownership of land by the government (as was done by royalty in England) and providing long-term leases to those who pay for its use. This method provides an opportunity for controlling the larger environment in the interest of all citizens (where citizens are seen to have such community rights), while allowing greater economic freedom for the kinds of structures to be erected.

How each country might resolve the issue of making good on the implied contract proposed above is a subject for research and debate. This paper addresses the 'implied' question: if a shift occurred in housing policy in Western society, what would be the focus of research questions in national laboratories and how would the structure of research programmes be affected?

Thomas S.Kuhn in his seminal study of the structure of scientific revolutions uses the concept of 'paradigm' to define a complex set of beliefs, past achievements which form the foundation for a research community's further practice, and a defined field of knowledge required of new adherents (Kuhn, 1962). He points out that existing paradigms in the physical sciences are visible in the courses required of college students entering the 'field', the text-books they read, and the awards made to practitioners whose performance is evaluated as exemplary by their peers. He suggests that scientific achievements that share the two characteristics of being unprecedented enough to attract adherents away from traditional models and at the same time openended enough to leave all sorts of problems to be resolved in future work are, by definittion, new paradigms.

> Paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute. To be more successful is not, however, to be either completely successful with a single problem or notably successful with any large number. The success of a paradigm—whether Aristotle's analysis of motion, Ptolemy's computations of planetary position, Lavoisier's application of the balance, or Maxwell's mathematization of the electromagnetic field—is at the start largely a promise of success discoverable in selected and still incomplete examples. (Kuhn, 1962, p. 23)

and again Kuhn suggests:

> Political revolutions are inaugurated by a growing sense, often restricted to a segment of the political community, that existing institutions have ceased adequately to meet the problems posed by an environment that they have in part created. In much the same way, scientific revolutions are inaugurated by a growing sense, again often restricted to a narrow subdivision of the scientific community, that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which that paradigm itself had previously led the way.
> (Kuhn, 1962, p. 92)

Building on Kuhn's thesis, new, or revised, paradigms for housing policy would share two characteristics. First, they should be clearly new enough to provide tentative answers to the anomalies or paradoxes in the currently used paradigm (e.g. as happened with the Copernican model of the universe), and, second, they should present a myriad of unanswered questions yet to be resolved within the emerging paradigm.

The current paradigms for housing policies are recognized by looking for examples of actual practice in our laws, espoused theories, applications, and instruments. The current paradigm is clearly illustrated in the course of study taught in colleges and universities to those coming into a field, and by the papers presented at professional meetings by those who teach and practise in the field. To the extent that we can say that 'housing' represents a field, it seems reasonable to say that the range of persons and papers presented in this volume are illustrative of the present paradigm for housing in Western society. Kuhn provides a potent suggestion to this community when he says:

> …again, if I am right that each scientific revolution alters the historical perspective of the community that experiences it, then that change of perspective should affect the structure of postrevolutionary textbooks and research publications.
> (Kuhn, 1962, p. ix)

If a new paradigm emerged based on housing rights, the building research laboratories of Western society would be required to modify their research base to be responsive to new national policies geared to these housing rights. The next section explores how research in our national laboratories might be changed to reflect a shift of this magnitude.

9.5 A NEW SET OF RESEARCH PROGRAMMES

If a shift occurs in housing priorities based on the rights of citizens, new research agendas would become important to national building research institutions in Western society. Although a wide variety of research programmes are likely, with differences between countries based on their laws and traditions, there are essentially four areas relating to designing and producing housing in which fundamental changes are possible: (1) the methods and tools used by workers could experience a technological shift; (2) new institutions could be created to operate outside the existing patterns of design and production; (3) a major shift could occur in the availability of resources; (4) one or more of the rules (laws) determining the relationships between workers, organizations, and/or resources could be changed.

Examples of changes in the past illustrate these possibilities:

1. the use of power tools, which gradually developed in the middle part of this century, substantially changed the hours required to complete traditional tasks of construction;
2. the application of computer methods to the design and engineering of buildings is now changing the time required to accomplish most of the traditional tasks of design (and may soon change the fundamental approach to building design);
3. a clear change in the organizational structure of work occurred with the introduction of labour unions early in this century;
4. a change is now in process in the United States (and has reached full development in Japan) to vertically integrate the design, production, erection and management of housing units within one company;
5. change introduced by the availability of natural resources is dramatically illustrated by the design of houses in the early history of America, when wood was the primary resource, as contrasted with traditional houses in Europe;
6. the use of manmade materials (such as ceramic Palc in Japan) is evidence of possible shifts in the use of natural resources;
7. changes in the rule systems incorporated in national housing programmes, union practices, building codes, and zoning ordinances have all had their impact in this century on housing processes.

A new research agenda for a new paradigm would involve both improvements in current research practices, and significantly new approaches and directions.

9.5.1 Laws and regulations

In the future the area of research likely to show the most dramatic results in housing programmes would be based on introducing changes into the laws and regulations governing relationships between skilled workers, resources, and tools, as well as marketing and management policies. This area of research is far different from existing programmes in national laboratories. It will require new attitudes about the development of research agendas, new kinds of staffing, and new means for disseminating results. New research within this area would address a wide range of topics, including the following.

Land control and development strategies

One of the most important areas for creative research under new housing priorities will be an examination of the rule systems impacting ownership and use of land. It seems clear that a separation is required between the rights of ownership (an alienable right that can be transferred with the title at the time of sale, or given to one's heirs) and the rights to control and use land. The present model of free enterprise markets as a determinant of land use favours the spectacular at the expense of those with modest or low incomes, and the model of socialist policies that gives the state all rights tends to remove natural incentives for care and improvements by occupants of dwelling units. This issue has been the subject of serious study by scholars for many years. It is time to move it on to the national agenda of nations committed to housing as a right of all citizens.

Access rights for infrastructure support

Community networks providing water and sewer services, information and communications, energy supplies and waste management, movement for goods and persons, and responses to emergency conditions, all need to have land use rules that primarily are responsive to the 'rights' of citizens to a fit environment and have the protection of private property rights as a secondary concern. The land-taking actions of communities for infrastructure installation are too often constrained by ancient legal concepts. The development and implementation of such rules changes will require much study and legal testing in the courts.

Life safety and public support systems

Historically, life safety protection and public support for emergency situations have been constrained by the successful efforts of insurance companies to protect the value of property first leaving the safety of citizens as a secondary concern. For example, fire insurance in the United States is largely protected by laws which require sprinklers for property (thus preserving long-term value of the property or reducing the cost of replacement) while paying limited attention to human safety and rescue operations. Reducing the number of fires in the US would change the actuarial base and constrain the premiums paid to fire insurance companies. Research on true fire statistics and life protection measures could dramatically influence the housing rights of citizens.

Education and health care facilities

Public support for educational and health care building programmes is geared to community revenue for the construction and maintenance of school buildings and catchment areas for hospitals. This concept, at least in the US, assumes that there should be a relationship between the assessed value of property owned by citizens of a school district and the quality of the facilities provided for the education of children who live in that district. This is a legally convenient way to preserve high quality schools for those who can afford to own their homes, and to leave the balance of the population to some form of social welfare. Ideally, the core of the 'right' to a fit environment is the notion of having decent educational, health care and other social service facilities and programmes, as well as dwelling units. How the rules systems can be changed to make public facilities responsive to public needs will take a lot of work. Old ideas will never be displaced without fresh, new ideas to put in their place.

Programmes for senior citizens

The 'rights' of senior citizens are no less than those of the young. A better job has been done in the US of building facilities for the elderly, and of making such places affordable, than for the balance of the population. With the rapid increase in the elderly sector of the population, a great deal more research is needed to keep the rules and regulations undergirding access to such facilities up to date.

To accomplish these purposes and the financial programmes discussed below, national building research programmes will need to retain professionals with education and experience in such areas as law, public policy, education, health and finance. The practice of research based on physical science models and engineering formulations will have to be broadly expanded.

9.5.2
Financial programmes

Financial occupancy

Along with dramatic changes in the basic rules and regulations governing the use of land, the provision of facilities for public services, and the regulation of life safety, new concepts (which lead to new programmes) are needed for financing the implementation of 'rights'. The simple argument that fundamental change is not affordable has to be countered by new concepts of national wealth and the distribution of a nation's productivity gains to all citizens. As the quote from Robert Reich in §9.2 indicates, 'the highest (income) earners now inhabit a different economy from other Americans'. New ideas, based on solid research, might well find ways to grant rights to the lower four-fifths of the population without forcing economic adjustments on the top fifth.

Studies are needed to explore how citizens of modest means can acquire rights of occupancy without paying exorbitant fees (usually based on a fixed percent rather than a fair price for services rendered) to those tangential to the transaction—e.g. lawyers who do title searches, real estate brokers, insurance underwriters, bank loan officers.

Financing infrastructure

National programmes for creative financing of intercommunity infrastructure networks affecting housing and other components of the built environment are needed. Financing the design, construction and operation of new magnetic levitation transportation, critical waste management distribution systems, educational television, public health information networks, are all subjects for study.

Living in a 'decent environment' and still having access to work is a function that needs to be supported by the community, not imposed as a private burden on the individual. There are good reasons why the more affluent would benefit as well. For example, a large number of communities in the US have become so expensive and so large, that no homes are available within reasonable commuting distance for the skilled workers who keep the public and private institutions operational. Operators of public transportation, school teachers, maintenance personnel and police and fire-fighters are all affected. A community is not a fit environment without these supporting personnel, even if the houses are elegant.

Research activities designed to explore new methods of funding design and development of community networks need to find ways to extend the true costs of community support to all citizens who use such networks. In many large cities of the United States, network services are provided by the central city to those who live and pay taxes in surrounding communities. This inequitable system has been largely perpetuated by so-called Councils of Government which make policies for regional programmes designed to assure surburban communities that their citizens will not have to bear the cost of inner-city programmes. One area of research that seems capable of contributing to solving the problem would be based on road pricing, based for example on sensors in the roads coming into (and leaving) central cities. Such sensors pick up registration information from electronic devices in each automobile to automatically bill suburban commuters for their use of the cities' networks.

9.5.3 Processes

Research projects in most national laboratories are intended to provide potential improvements in the design and production processes for buildings. A shift in national priorities towards housing as a right would broaden the list of such projects.

Creation of shared community service organizations

The British New Towns programme included the design and development of new institutions, at the community level, for education, health care and other social services. The United States has generally not included this form of development in housing research. Any requirement for a fit environment should clearly provide such community services. For example, in most American communities a large demand exists for day-care support.

The design of dwelling units

While the design of dwelling units has been a part of the research agenda for most national laboratories, new emerging diagnostic tools and methods suggest a strategy change for this research in the future. The revised strategy would link explicit performance criteria used as a basis for design decisions with diagnostic procedures undertaken after occupancy to provide feedback for improving future designs. The design of dwelling units based on 'opinions' of architects alone should be advanced to a more systematic methodology.

The production of dwelling units

Methods of fabrication, both on the site and off the site, generally have led to productivity improvements in the construction of larger buildings rather than housing. Sweden has amassed an impressive record of process improvements in off-site fabrication following a decision to provide quality housing for all citizens. It was necessary to organize a large-scale pre-fabrication capacity to fulfil this national mandate. The Swedish experience demonstrates that establishing national priorities for housing can have a major positive technological impact.

The management of housing units

Housing management is another area high on the agenda of many national laboratories, but not all. Laboratories completely dominated by the research models of physical science and engineering have not viewed design, production and management issues as appropriate concerns for research. If national priorities change, and, subsequently, the agendas of national building research laboratories are expanded, then technical issues of management would be included. The development of diagnostic tools (mentioned above) is an example of one area of study.

9.5.4 Products

The present concerns in Western society with environmental protection are beginning to impact resource consumption and the use of materials in construction, e.g. the prohibition against asbestos products. It is clear that materials-related research, at both the basic and applied levels, will find these concerns a major infuence in the next few years.

A list of areas of research fitting this more traditional agenda of national laboratories is given below.

The Site as a Setting
Foundations and geological engineering
Earthquake design
Plants and ground cover
Indoor hydroponic plantsThe Community Systems
The movement systems within the community

Interfaces with external transportation
The energy systems within the community
Connections to larger networks of energy
The information/communications systems
Connections to larger networks
Police and fire protection
The waste-management systems of the community
Input/output to the outside
Recycling as a system.

9.6 WHAT ARE THE PROBLEMS OF EFFECTING CHANGE?

The original assignment for this paper was to address the 'problems of effecting change' in housing research including research into practice (relationships between innovators and entrepreneur), public perceptions and promoters' prejudices, the role of governments, education and training for future technologies (professionals and artisans).

9.6.1 Limited research agendas produce limited results

The theme of this paper suggests that the agenda of research undertaken by building research laboratories around the world changed very little in 40 years and, consequently, to seek ways to remove barriers to the use of such research was not an issue of major importance. It is likely that a relationship exists between the perpetuation of a limited research agenda by national laboratories and the f fact that support for building research has declined in all Western countries, including the UK and the US. While many have been critical of the architectural profession for devoting so little time and attention to building research issues, perhaps the profession has also sensed this lack of progress. Or, perhaps the tendency to organize research around subjects within the domain of the physical sciences has been seen by architects as irrelevant to the design problems they face (architects are, of course, not correct in this assessment, but they often lack the technical knowledge required to understand the results of physical science research).

9.6.2 Weapons and space research produce no spin-off

It would be reasonable to assume, and many members of legislative bodies do so, that the huge sums devoted to research in weapons, space and nuclear energy (in the US these three areas have dominated the nation's research agenda, obtaining more than 75% of all R&D funds since World War II) would produce spin-offs for housing. The transfer of results from these three dominant programme areas to building design and construction is minimal. In fact, it might be possible to argue that housing research has been retarded by the dominance of the big three because the success of physical science research applications in weapons and space has suggested the model can be applied to any problem area. It is not uncommon to hear an American say, 'If we have been able to land a man on the moon, why can we not solve the problem of affordable housing?' The seduction of this logic has made it possible for scientific institutions to assume the mantle of wise advisors on national problems from poverty to homelessness.

9.6.3 University research lacks impact on education

Universities might well be considered as places for new ideas and advanced concepts to emerge. And they have been, in the United States, in the three areas mentioned above. Architecture and civil engineering programmes in US universities often, but not always, include research programmes. However, research in schools is almost entirely divorced from the educational programme of undergraduates. Continuing education programmes for professionals in practice also make little use of university-based research.

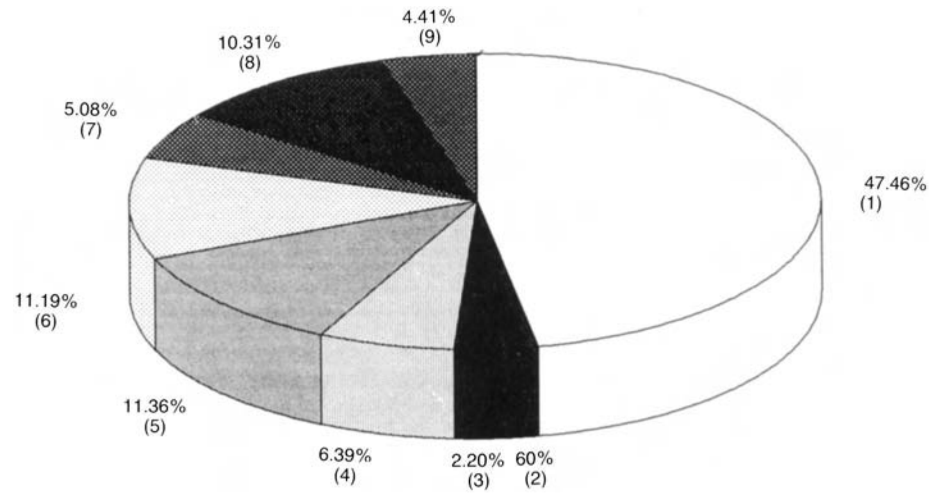

Figure 9.1 Land development costs ($59000 total). (1) Raw land, (2) taxes, fees, insurance, (3) engineering, (4) soil testing, (5) sewers and water, (6) paving and kerbs, (7) interest, (8) miscellaneous, (9) contingencies.

9.6.4
Government-sponsored research failures

When science became the hot subject for Washington after World War II, no Federal programme was thought appropriate unless it had an R&D component. In 1958 the Housing and Home Finance Administrative (HHFA) received $2 million from Congress to undertake a research programme. HHFA was a popular agency because it was making it possible for returning servicemen to buy homes. Congress believed that R&D (which has proved to make such a major contribution to the war effort) was surely a good idea. One of the major components of this innovative programme was organized by university-based social and behavioural researchers. They were determined to find more data on consumer needs that could be used to modify the 'minimum property standards' of the HHFA. Within two years this new research programme was killed by housing industry lobbyists who were concerned that government-funded research could upset the 'delicate balance' of materials and equipment markets in the housing field.

In 1964 the Science Advisor to President Kennedy, Dr Jerome Wiesner, and the Assistant Secretary of Commerce for Science and Technology, Dr J. Herbert Holomon, created a new research programme to stimulate research in the industrial sectors outside the traditional weapons and space programmes. This programme, called the Civilian Industrial Technology (CIT) programme, included a component for the building industry. After less than one year, this programme was killed by the same industry lobbyists who had stopped the HHFA programme 16 years earlier.

In 1970 the Department of Housing and Urban Development began a programme called 'Project Breakthrough'. The intention was to stimulate innovations in housing by inviting companies with successful records of R&D in the weapons and space fields to enter the market. A good deal of money, by housing industry standards, was wasted because there was never a clear policy of how housing markets of sufficient size could be created for these innovations, and because the research was largely devoted to product ideas (with the required process changes, land assembly, and financing packages left to traditional home builders).

9.6.5
Housing prices are more than housing costs

One of the largest barriers to effective housing research is the belief that problems could be solved if something could be done to reduce the cost of labour in building a house. As Figs 9.1–9.4 illustrate, the cost of carpenters in a typical American house, which sells for $195000, is less than 7%. If their labour were to be reduced by 50% (a goal no research programme has even aspired to) the cost to the developer would drop by 3%, but it is unlikely that the price to the buyer would be reduced. The cost of developing the land, paying for all of the developer's overhead items, and financing costs for construction far exceed even the costs of materials, much less the cost of labour. Until the research community (and architect) face this reality, we are not likely to deal effectively with the question of affordable housing.

These kinds of barriers continue today. The status quo is firmly in place and will not be dislodged without a major shift in the housing paradigm induced by political will.

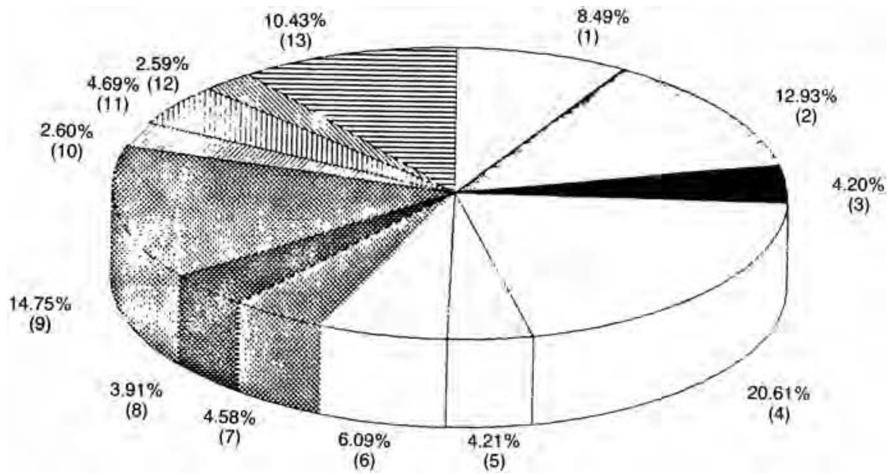

Figure 9.2 Housing component costs (carpentry, $7700; total costs, $90698). (1) Carpentry, (2) digging and foundation, (3) permits and inspection, (4) materials for house, (5) roofing, (6) plumbing, (7) HVAC, (8) electrical, (9) interior finishes, (10) painting, (11) kitchen equipment, (12) contingencies, (13) interest and overhead.

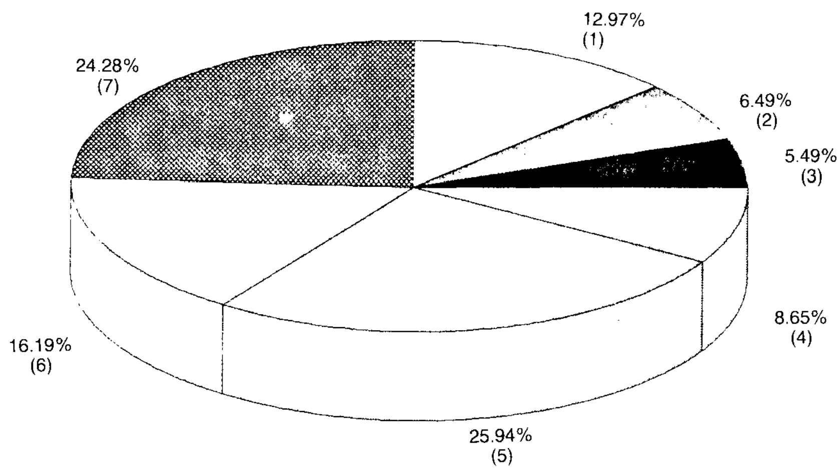

Figure 9.3 Developer's costs for house (total, $45548). (1) Sales commission, (2) closing costs, (3) marketing costs, (4) advertising, (5) adminstrative costs, (6) income tax, (7) profit.

9.7
SUMMARY

Major changes in the housing industry are unlikely until there is first a change of political will. While research programmes in either national laboratories or universities can continue to provide marginal additions to the knowledge base, and minor modifications to products and processes, no dramatic results are possible within the present political climate. Finding ways to remove the barriers to supporting or utilizing the traditional research programmes in housing pales in significance when compared to finding ways to shift the basic paradigm of housing. Affordable housing for our citizens with modest incomes, much less the more difficult problems of providing shelter for the homeless, will not likely result from any effort made to remove the barriers to the use or support of research as currently conducted.

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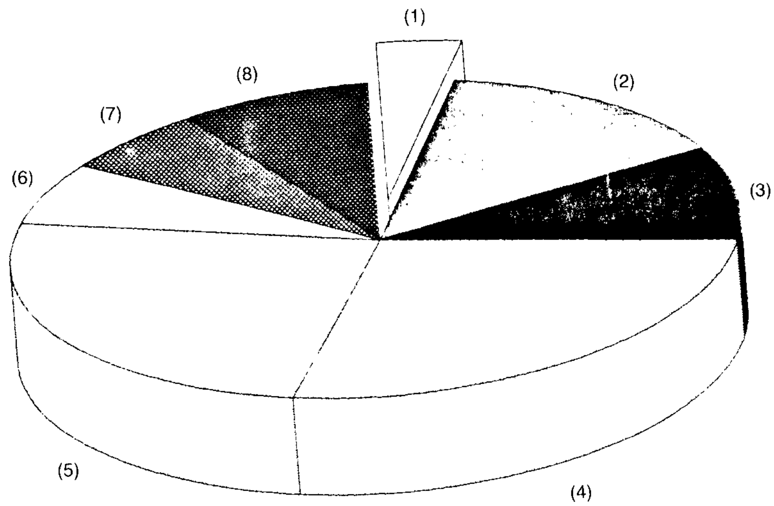

Figure 9.4 Total sales price for house, $195246 (carpentry costs, $7700). (1) Carpenter, (2) developer overhead, (3) developer profit, (4) house materials, (5) land development, (6) miscellaneous house costs, (7) miscellaneous land fees, (8) sub-contractors.

10
Summary of presentations

R.Bender

10.1 INTRODUCTION

This has been a stimulating two day s of discussion. The topic, the participants, and the setting (here at the Royal Society) which brought them together and encouraged the exchange of ideas have made us all think more clearly.

But thinking about the future, especially about 'the next millennium', is intimidating. In addition, progress is 'discontinuous'. There are moments or periods of great discovery, of new and revolutionary conception, followed by long periods of stability; of verifying, quantifying, filling in and refining. There are also times of confusion and ferment, times when changes in facts, institutions, technology or beliefs show us that the old concepts are no longer valid but in which new concepts have yet to emerge. We live in such a time today.

Given this situation, how can one summarize this discussion? How can one summarize a meeting which has involved such different themes and such different perspectives?

On the plane coming to London I thought: Perhaps I can do it by summarizing the jokes. The stories people tell in introducing a talk are often cues to our memory and metaphors for the point they mean to make. Unfortunately, the jokes, too, were too varied to provide a clue to how to bring it all together.

Next I thought: One way to give it an order is to treat the individual presentations like the 'patches' in a quilt. A quilt uses different pieces, assembled from different sources. But one starts a patchwork quilt with a pattern in mind: a 'Nine-patch' or 'Log Cabin' or 'Schoolhouse'. All I seem to have is what is called a 'Crazy Quilt'.

Then as I struggled with the notes from the first day's sessions, looking for a conceptual framework for it all, I thought: What I really need is a filing cabinet. Let me explain and see if I can put some light on our dilemma with this analogy.

Coming to a new conceptual framework and the process that makes it necessary can be illustrated by comparison to a developing architect's filing system.

The young architect begins to collect information while he or she is a student (building types, perhaps some good details and a standard spec, eventually a product catalogue or two). Perhaps they are kept in a drawer or on a shelf. Eventually, they are moved into a filing cabinet of some sort. Finding things is easy. There are few categories, and not many items; at any rate, the items and their contents are familiar.

As a practice develops, more and more material is collected. Building product information, contracts, and papers from old jobs, more detailed cost and specification material. It becomes hard to find things quickly until categories are systematically organized. First, our young architect tries separating product information from past jobs, then ordering product information by trade. But this, too, got messy. Does tile go with finishes or bathrooms? Where do you put sliding doors? Again, the solution is easy. A little research uncovers the AIA filing system. He orders it and our architect is back in business with a place for everything: floor materials, windows, insulation, studs, etc. All have numbered categories.

Then one day a catalogue comes in the mail. It is a wall panel. Where does it go? Window, door insulation and finish are all combined in one product. Well, it's a little sloppy, but not so hard to patch up a solution. Just Xerox a few copies and put a copy of the catalogue in each section. This works for a few things, or simple combinations, but it is expensive, takes up space, and is messy. There are other methods. Set up a new category. (But which one, and where does it fit?) My own solution has always been to make a miscellaneous file. Miscellaneous files are good for this sort of thing. They disguise a lot of confusion.

But soon the miscellaneous file starts growing. It develops its own sub-divisions and eventually is bigger than all the rest of the file. This is what our computer friends call *information overload;* more information than can fit the concept. It is time for a new way to file the information. A way in which all the information we now have can be usefully included. We are ready for a *conceptual change*. A new way to look at our world: a new paradigm for the new millennium.

In our time this new paradigm may mean looking beyond individual buildings to the total environment as our end product. Surely, it will involve the creation of a new intellectual framework to organize the effects of the enormous social and technical changes around us. So, let's look into the miscellaneous file, then speculate on some varying paradigms for the future of housing.

In his opening address, Sir Michael Atiyah seemed a little uncomfortable about the idea of a meeting on housing at the Royal Society. Housing is a messy subject, it is 'not scientific', not 'hard'. Its themes are living, love, family, sociability, and self-expression, none of which is easily quantified or measured. In housing, sunshine may be more important than solar energy, and community and comfort are more important than strength and durability.

Housing is messy. It is like living, like life itself. Certainly difficult to quantify, often hard to explain. Perhaps science and the scientific method— which has solved so many of the world's problems in this last millennium, and at the same time has created even bigger problems—is not the most appropriate tool for the next millennium. Perhaps we should be less afraid of art. As we organize a new conceptual framework, we might look at Leonardo for a model. He felt comfortable and gave us great gifts in both worlds. Dr Allen continued the theme set by Sir Michael Atiyah, but added another dimension. As he traced the history of housing through the millennia, he pointed to an acceleration of the pace driven by science, referring to it as the 'power tool of learning'. He pointed out that:

> We are facing the last decade of this second millennium, advantaged by the possession of geographical detail of our globe, considerable knowledge of its present climates, some measure of the limits of its resources, and a rapidly developing awareness that we inhabit a piece of planetary equipment that not only requires management, but that *it must* be managed if it is to provide the circumstances in which existence is both possible and meaningful for humankind and for whatever force it was that gave us meaning and this planet on which to develop in the first place.

Dr Allen went on to set the stage for the uncertainty which became a theme of our discussions as he said:

> We cannot say what will actually happen in the far distant future about housing or any other technology, but we can identify parameters of the problems it presents and thus provide growth points for constructive thought about the database that will be needed, for this must be gathered and structured continuously in a coherent and relevant manner for the purposes of good management on a global scale in the future.

He went on to make the point that this is the object which this conference was designed to address: What do changes in technology mean for housing? But technology is not all there is to housing. It also concerns

> …the needs of the human spirit and if they are not satisfied, the evidence is that there is sometimes not much point in building the hardware in the first place.

Finally, Dr Allen laid out the themes with which the meeting was structured: needs, expectations, and resources; climate and the response to climate; the materials, techniques and systems of housing; the potential for new technology and the barriers to change.

Here is one of the crucial issues for us to deal with. How to 'decompose', to organize the items in our miscellaneous file. Might we have had a different meeting—a different view of the future—if we had looked at housing as a part of our systems of public health, education, transportation, productivity and community? Might we do better by examining housing as a process of life rather than as a product of technology or business?

10.2
SUMMARY OF PAPERS

Professor Chisholm stressed that the future is going to present increasing problems to low-income countries; if we approach the problem in rational terms of business economics, the resources are not there. The populations of the poorest countries are moving towards the towns, and hence mega-cities represent the key problem of the future. For the first of several times at this conference we were told that the problems are not predominantly those of resources or technology but those of commitment and priority.

Mr Richard Best, pointed to the future redistribution of wealth such that, even with a stable population, the provision of rented houses in Britain and elsewhere is drying up. He pointed to three trends: (1) market economies are replacing state economies, (2) several social changes are leading to increased needs for smaller homes, (3) while it was inconceivable that mass world starvation could continue to be tolerated, he did not see mass immigration occurring into Britain. He saw extra funds finding their way into housing, people in Britain would have more leisure with a higher proportion spent in their homes, also greater investment into homes for old age. For many people, their homes would remain their castles, despite increasing mobility. His presentation left me a little uncomfortable, however, as to whether the future will take the form of the present middle-class dream.

Professor Max Fordham's approach to the building envelope considered an approach which focused on new ways to modify climate. Building types which combine healthy and attractive 'light centres' with efficient energy use are the result of intelligent market forces. He illustrated that adequate light in houses did not necessarily depend on large windows. Technology could now make use of optical fibres, double and triple glazing and new forms of insulation. The presentation left us with a challenge. There are many new tools and techniques. Can we develop new concepts of home and house? Or will all this simply lead to adding new hardware to the previous millennium's homes?

Professor Hendricks stressed how, in a cold climate, the major factor is the pressure differential. There is a strong need for performance standards in this area. Perhaps a bigger question concerns what is a house-home-dwelling: a decent home in a suitable environment? There is a great dilemma of the two worlds. I found it hard to feel that pressure control mechanisms are a priority for a world which contains many families who earn no more than $300 per year who need to make a home out of scavenged materials without a water-waste system.

I was sorry to get only a brief flash of the biosphere, a really interesting experiment that moves the scale from the autonomous house to the sustainable community. Here is a glimpse of a form of community which the next millennium may bring.

Professor Vigier spoke about how housing is produced in the third world. In the Western world, it has become a product—a finished product—which is too expensive to buy with cash. On the other hand, in the Third World, the inability to house our people is the result of lack of will (commitment). The energy of those who need houses is more than adequate but we need a new view as to how housing is produced. In developing countries, self-help is a mechanism for saving based on one's ability to be productive, providing housing for those who are (even) less affluent. A feature of self-help projects is that they grow incrementally. Perhaps the main value of studying the Third World is not to solve their problems but to learn their techniques for solving them. While Professor Vigier illustrated how self-help works for construction, there remains an underlying need for a parallel process of 'incremental infrastructure'. These examples of Third World housing show us construction not as a product of government but as an imperative result of life processes.

Martin Pawley had a valid criticism of the meeting in that he pointed out that the conference title did not prepare him for such a detailed discussion on the nuts and bolts of construction. He then, however, appeared to fall into a 'trap' by focusing on his own particular interests, those of recycling and 'one-way' packaging.

Mr Chemillier described some fascinating research to improve controls for comfort, for communications and towards new, more 'intelligent' buildings with systems of home automation, 'domotique', and the potential to integrate community security, fire protection, shopping, education and child-care with communication of all sorts.

Dr Kashino described the work of the Ministry of Construction in Japan including work on advanced materials, technologies and total housing systems with new methods of assessment of each. He illustrated his talk with a fascinating family of robots which, for instance, set tiles and finish concrete floors. In Japanese factories one can see modern robots building houses whose design evolved in the eighteenth and nineteenth centuries. Is this the future? A 1000m high building is an old fascination, an old mistake. But the autonomous-biological house may be a new direction worth pursuit.

Dr Robin Spence gave us a powerful picture of housing in the developing world where £100–200 is the budget for a house. He also showed that a regional approach and a technology appropriate for the people and the land can help to produce good housing and healthy communities. Of course we hope that the future holds more than £100 houses, but there is much for the 'developers' to learn from these projects.

Professor Eberhard in a moving presentation pointed to housing as an 'inalienable' right. The right to a place to live is as old as man, but the right to be given a place to live (or even to be able to buy a place to live) is newer, part of a growing specialization of society. A house was traditionally a product of 'homemaking'. Only recently have we made the product 'housing' and made people purchasers rather than participants. Dwellings are not unique in this respect. Increasing specialization has made people increasingly dependent on others for food, clothing, recreation, education, health care, and made them all products to be bought in a system that depends on speciality and scarcity. I found this a very important contribution, a new paradigm in which the right to a house becomes an 'inalienable' right. Until this view is accepted, we will make no real progress in housing for most of the people.

10.3
CONCLUSION

Finally, what are the ideas which have emerged to help us organize our 'miscellaneous file'? Here is one try. We are beginning to reorganize housing —the building of homes—as more than a product. The next millennium is likely to be marked by a view of the right to a home as a foundation of society: an 'inalienable right' for the individual and an essential component of a civilized society.

We can expect to work with a paradigm which views ‘housing’ as part of a larger whole; sharing space/costs/attention with other essential aspects of life: health, education, creation, recreation, transportation, and family. Locational decisions will be seen as aspects of decisions on air quality, public health, productivity, and recreation rather than large purchases of a ‘consumer item’. The conceptual framework within which we work will be built on the understanding that the two worlds (developed and developing) are not separate. Perhaps, they are mutually responsible to each other. Perhaps an important element of our research is to learn how to use successful techniques of both of these ‘worlds’.

In the future, housing will be seen as a process, not a product. It will be planned, designed, constructed, operated and evolved with the understanding that it goes on over time, involves participation and is interactive with all aspects of society.

Those who live and work in the next millennium will hold new views of the home and community, the process and the product. These will grow out of new views of how to decompose the elements of home and homemaking to fit the various activities, values, technologies, and values of future popula- tions.

We can expect the next round of development to be based on a less centralized view of the ‘housing industry’. We can expect it to be built around lighter, more dispersed elements linked together in rich and varied supportive networks. These will fit themselves into, rather than overpower, nature, and they will be systems to support rather than control life.

Looking back to the changes which have come about in the last millennium, it is clear that our wildest dreams are quite tame. Certainly, most of this meeting’s views into the next millennium are little more than a peek through the keyhole of an enormous room. We have heard little which will look beyond the first decade of the next century. The future, for those of us who live for and work to improve the quality of the built environment, is a wonderful challenge.

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