The potential for zero emissions/energy development in China

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ABSTRACT

China is rightly regarded as a country in which progress on developing sustainable and low energy solutions for building design is essential. The size of the population, the rapid urbanisation that is taking place, and the reliance on fossil fuel based energy sources, not only make this a priority for China but also for the rest of the world. The concept of zero emissions or zero energy buildings has been in existence for many years in the UK and other developed countries and more recently has evolved to larger scale examples such as the development of complete housing schemes. This model has been investigated for implementation in China. The work involved a survey of current activity both in China and elsewhere; it also involved survey of designers and potential purchasers of housing to investigate the degree of knowledge and understanding, and willingness to include sustainability issues in the design and purchasing processes. The principal findings of the research indicate that though there is a general awareness of the topic and issues, that it has so far made only limited impact; however there is a degree of untapped opportunity. Some of the key issues relate to economics, lifestyle and a need for greater understanding.

1. INTRODUCTION

The work reported in this paper describes findings from part of a larger scale project investigating many issues associated with the implementation of sustainable low energy buildings, understanding and practices in China. The concepts of zero emissions or zero energy development are intrinsically associated with the approach. This paper is particularly concerned with attitudinal responses discovered from surveys carried out.

China is the world's most populous country and its citizens are engaged in a rapid urbanisation process. The country also relies heavily on fossil fuels to meet its energy demands and a large fraction of that supply is carbon intensive coal, accounting for 65% of its primary energy consumption in 2002 (EIA, 2004). The Chinese economy is also growing rapidly, at approximately 10% per year (EIA, 2004). All of these factors conspire to indicate a potential time-bomb in terms of explosion of carbon dioxide emissions leading to accelerating global warming.

At present, energy use in buildings is lower proportionately than a number of western countries for historical reasons and the fact that provision of heating and cooling systems at domestic scale has been restricted in some areas of the country. The situation is beginning to change however, current energy use in buildings is about 23% of the national total but rising, with expectations it will account for 33% by 2050 even allowing for efficiency savings (Energy Foundation, 2005). New urban professionals are beginning to aspire to the lifestyles of western counterparts and with this comes the need for new housing and the energy consuming systems that provide comfort and convenience. Air conditioning systems are one symbol of the new affluence and by the late 1990's new air conditioning systems were being installed at a rate of 3.5 million per year (MIT, 2004). Total energy use is also increasing at a dramatic rate in China so that 33% as a proportion for buildings actu-

ally implies a very significant rise in absolute terms.

This paper addresses in particular the needs prevalent in the housing sector in the major cities of China and takes as its main focus the most important commercial and industrial city of Shanghai. Energy conservation policies for building have in fact been in place since 1986 but lacked a degree of definition. There was also little post-construction testing or inspection to verify compliance (a situation unfortunately found in many countries). In Chinese cities building progresses at a remarkable rate but unfortunately the predominating concern is to build quickly, not sustainably. Changes are taking place however such as new draft building codes being developed (Shanghai Municipality, 2004).

A number of international collaborations are now underway to help showcase low energy environmentally sensitive buildings (MIT, 2004; NRDC, 2004; ACCORD21, 2005). In this paper however a different approach is taken; studies have been carried out that focus on the awareness, knowledge and understanding exhibited by local designers, developers and potential occupants of new housing. This should permit better targeted research and development focused at the local scale.

2. ZERO EMISSION DEVELOPMENT

2.1 Concepts

Various concepts of low energy and low impact building have developed over recent decades – *autonomous* houses, *zero energy* houses, *zero carbon* houses; each with their own calculation methodologies of environmental benefit (see for instance Vale and Vale, 2000). A phrase with contemporary attributes is that of *zero emission development*, often abbreviated to ZED. This term has also been used to refer to *zero energy development*. A chief exponent of this approach has been the architectural practice of Bill Dunster (Dunster, 2005); the major built example of this approach being found at Beddington in London.

2.2 BedZED

BedZED is the Beddington Zero Energy Development (Fig. 1) which is a housing based scheme in the London Borough of Sutton; it also contains some mixed-use commercial units and some community facilities. It has been well documented (for example Pitts, 2004) and has received widespread publicity. BedZED came into being through the coordinated efforts of a knowledgeable architect, expert consultants, and appropriate financial backing from a development organisation. One of the key elements was the local approach taken; the development was instigated and planned by consultants and designers very familiar and active in the local area and with local knowledge. It would therefore seem sensible that if the model is to be used elsewhere that it is more important to focus on local rather than national issues, and local rather than national participants.

Figure 1: Beddington Zero Energy Development.

BedZED has many environmental and energy efficient features:

- *High density and efficient land use.*
- *Transport policies to restrict private car use.*
- *Multiple passive design features including solar access for all properties.*
- *Outdoor space for all properties.*
- *High fabric insulation including windows.*
- *Airtight construction.*
- *High thermal mass.*
- *Heat recovery ventilation.*
- *Most materials sourced locally.*
- *Combined heat and power plant using waste timber carbon neutral fuel source.*
- *Integrated photovoltaic system.*
- *Low energy and low water-use appliances.*
- *Rain water and waste water recycling.*

The development has helped to satisfy a demand for housing that is acute in the London

area (as it is in many developing countries and their cities). It also uses a series of rental and purchase options to suit the needs of differing groups of occupants. There are some modest lifestyle changes required from the occupants of the dwelling units too - less reliance on private transport and an understanding and appreciation of the environmental systems and design features. There is also clearly a need for understanding and expertise from the design team as was shown at BedZED.

Despite the relatively high density of the BedZED development it is still rather low by comparison with that both required and found in many city developments of the Far East and Pacific Rim, including Chinese cities. A multi-storey alternative has also been proposed by the same architects - *SkyZED* or the *Flower Tower*. This shows some similarities with the bioclimatic skyscraper designs of Ken Yeang (Yeang, 1999). Dunster has also led initiatives for larger scale urban development (*Velocity*) and been involved in urban design proposals for Jintan, located about 1.5 hours drive from Shanghai in China.

2.3 Hong Kong

The city of Hong Kong also provides an interesting alternative example for green design. The city has a very hilly topography meaning that only about 50% of the land area can easily be built upon. That part on which building has occurred has extremely high density however - as high as 50,000 people per square kilometre. The city is extremely efficient in many ways. The per capita carbon emissions are low by comparison with Singapore, Japan, UK and the USA; indeed they are not much greater than that of the rest of China (Pitts, 2004). Space and transport are both used very effectively: homes are relatively small in area and well integrated into mixed-use blocks and neighbourhoods; transport is largely public not private, and is both cheap and convenient. Innovative 3-dimensional movement systems are used, such as escalators on the hillside of Hong Kong Island that move people down into the city in the morning and up in the afternoon (Fig. 2).

The efficient use of space is also enhanced by opportunistic approaches to development in which multi-storey blocks have dwellings on upper floors, commercial offices lower down and retail at low level. Community facilities and transport systems are also part of the development. A person can therefore walk to satisfy many day-to-day requirements; an urban village in a single block is quite possible.


Figure 2: Hong Kong 3-D people transport systems.

Buildings in Hong Kong certainly require energy for servicing, and air conditioning systems adorn the facades of many apartment blocks. Changes are taking place however: there are some interesting innovative developments now to be found and designers are starting to be provided with the skills and understanding to optimise performance. Environmental rating systems have also been developed and have been used to some significant effect.

2.4 Issues for Chinese cities

The foregoing information sets out some ideas that can have impacts in the cities of China. Around the world there are examples of what can be achieved in terms of high density, climatically sensitive, sustainable developments. The task is to persuade those engaged in designing and purchasing that low energy sustainable housing is a possible solution. Air pollution in Chinese cities is also notoriously poor; energy efficiency measures can reduce emissions and impacts. In the remainder of this paper the focus will turn to the examination of attitudes and awareness in Shanghai.

3. POTENTIAL FOR Z.E.D. IN CHINA

3.1 Shanghai

Shanghai is often regarded at the Chinese equivalent to New York. It is perhaps the pow-

erhouse of the country's development: the GDP of the city trebled in the 1990's. It is a high density city and also a high energy consumer (about three-quarters of which is sourced from coal) and has the highest per capita carbon emission of all Chinese cities. Between 1990 and 1998 residential building increased from about 4 million to 16 million square metres per annum (MIT, 2004). The energy supply systems are under strain however with peak period power restrictions reported in 2004.

Environmental conditions in the city vary considerably between winter (when there is a need for space heating) and summer (when there is a need for cooling). Humidity is also generally high. Passive design features, which are not well exploited at present, offer some opportunity for improvement in comfort conditions and also in energy consumption. Cross-flow ventilation is a particular strategy valuable for summer conditions. There are many options however and in this study it was decided to focus on issues arising from the study of Zero Emissions/Energy Development. These were perceived as offering relatively easy, attractive and affordable potential improvements.

In recent years one of the significant variations has been the movement from publicly owned housing to privately owned housing. The market is not yet very mature however.

3.2 Surveys

Surveys were carried out to investigate the attitudes and understanding of both designers and building occupiers during the summer of 2004. Different questionnaires were developed for use with the two groups and were provided for distribution in the Chinese language through a series of professional contacts in the city of Shanghai. The questionnaires sought responses on a number of topics and related to attitudes towards dwelling attributes and sustainable design features; knowledge and understanding of the technologies; and of issues important to the persons concerned.

The number of responses from potential purchasers was considerably larger than that from designers and data must be examined with due care, however there were some significant and interesting findings.

4. SURVEY RESULTS

4.1 Designers

When designers were asked about sustainable development in housing 68% claimed good understanding of the topic and thought that environmental issues were the main concern for the design process (rather than economic, social or human issues). When asked to identify the five most important sustainable design features, sunlight and natural ventilation were most often quoted. Figure 3 shows the summary of responses.

Designers were also asked about whether they included features identified in figure 3 in their designs. Over half replied 'yes' or 'some of them' with a further 40% claiming they would if

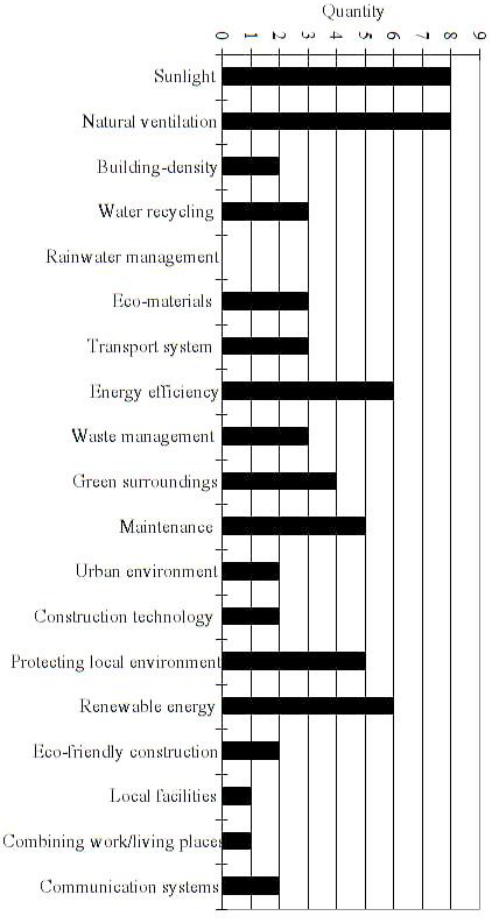

Figure 3: Designers choice of main features for inclusion in sustainable housing.

the budget permitted; these responses are very encouraging. They also stated however that clients only occasionally asked for sustainability features (76% of the time). They expressed a willingness to explain sustainability concepts to potential clients if requested, though ultimately they placed the largest burden on the government for persuasion in favour of sustainable design.

4.2 Purchasers

The responses from potential purchasers were not so encouraging on the whole. Sixty-six percent were unclear or did not know about sustainable design, though 54% thought they would be in favour of sustainable development as part of housing policy.

The responses to the kinds of features that purchasers would take into account in choosing housing was very widespread (see Fig. 4); price, location and local environment being the most highly rated; sustainability exceeded only ‘neighbours’ and ‘style of living’ in importance.

When asked the same question as designers concerning the five most popular features they would find important in their daily life, some differences to those considered by designers was shown (see Fig. 5). Sunlight and natural ventilation were still seen as important, but transport systems and green surroundings were also highly rated. Some important features of sustainable housing were low rated and this indicates a lack of awareness or interest on the part of potential purchasers.

When it was explained that housing design was important for sustainability and the purchasers were asked if they were willing to spend more on their properties, 70% replied in the affirmative (40% up to 5% more on price; 30% up to 10% more on price). This is a very positive result and indicates that though potential purchasers may not be particularly knowledgeable they are willing to take the issues into account. Clearly there is scope for education and the raising of awareness in this area.

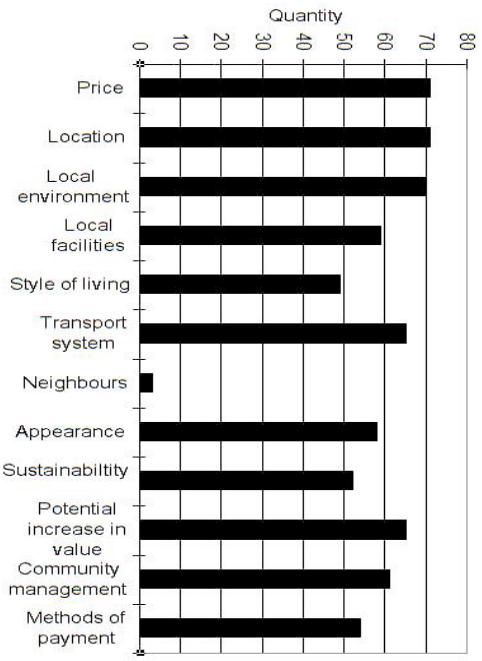

Figure 4: Purchasers main concerns when choosing housing.

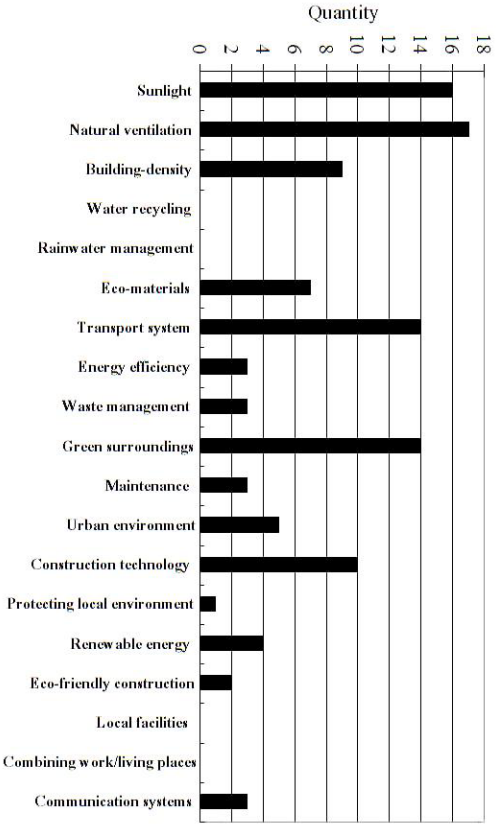

Figure 5: Purchasers choice of main features for quality of life/sustainability.

5. CONCLUSIONS

Improvements in sustainable design and energy efficiency are urgently required in many countries around the world. China with its large population and rapid house building programmes must be an important contributor to improvements deemed necessary. Some important changes are already taking place but there is room to make further advances.

The pressures to build have meant that building regulations that support low energy design and sustainability may not have been enforced as rigorously as might be required (again a situation found in many developed countries). It therefore seems appropriate that most impact might be achieved by education and encouragement for designers and the general public (ultimately the clients). This might also be linked to education about the relationship between lifestyle and sustainability.

Developers in Shanghai operate the same way as in many other countries - the UK for instance. They seem to concentrate on building housing that simply matches to expected price/type combinations for an area/locality and therefore maximise their profits by minimising costs. Sustainable design is often perceived as having a higher cost, though this need not be the case (Pitts, 2004), but as a result is not included in design. It is also not often asked for by occupants, who either do not realise its value or who are preoccupied by other concerns.

An example of a good quality sustainable housing development, along the lines of the ZED concept that engages and integrates with the locality, would provide a strong focus for future development.

It is clear that there is much more to be researched in this area and certainly much more to be achieved, but there are great possibilities that have yet to be tapped. Potential for zero emission development does exist in China but certainly has not yet been exploited.

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