

# A Socio-Technical Perspective to Enact Zero Emissions/Energy Development in China

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**ABSTRACT:** Based on the widely acknowledged concept of 'sustainability', low energy architectural design is rightly regarded as an essential issue in China. However, like the experiences in many western countries, most piloting research work has been concentrated on detailed high-tech approaches. Since the developmental circumstances are different, it becomes very questionable whether these kinds of technical fragments would successfully meet the particular requirements in China. In this paper, the concept of 'zero emissions' or 'zero energy development' has been brought forward as a proposal. Through the case study of Beddington Zero Emissions/Energy Development (BedZED) in the UK, the feasibility of enacting this kind of housing development in China has been discussed. As a sustainable housing project in the UK that has been extensively investigated, BedZED demonstrates the innovative thinking, of designers, developers and consultants, not only for the integrated technical add-ons but also for the intrinsic lifestyle change. The principal findings indicate that the aim of sustainability can only be achieved by the close cooperation between all stakeholders. And as an alternative interface, the socio-technical perspective will become the essential of all accordingly. Some of the key issues relate to trans-disciplinary discussion and a need for greater understanding.

**Keywords:** socio-technical, sustainability, ZED (Zero Emissions/Energy Development), lifestyle,

## 1. INTRODUCTION

Sustainability has been widely acknowledged as an important concept in the world, following with people's increasing concerns about climate change, energy consumption and carbon emissions. However, most of the piloting research works are concentrated on detailed high-tech approaches. This sometimes results in a misunderstanding in perception and drives designers to see sustainable design strategy as an evolution of 'high-tech style' in contemporary architecture. Moreover, it is also very questionable whether these kinds of technical fragments could successfully meet the criteria of sustainability. In China, since low energy design has rightly been regarded as an essential issue in the architectural domain, a further debate has been raised within this circumstance – as the world's most populous country yet with a relatively low technical level, whether those detailed technical measures borrowed directly from the western countries could successfully satisfy some particular requirements? Or in other words, is it a right way to pursue sustainability in China through a perspective focused on technical aspects only?

In the UK, some sustainable strategies, like Zero Emissions/Energy Development (ZED), have been in existence for many years. And the Beddington Zero Emissions/Energy Development (BedZED) is one of the large-scale complete housing schemes designed, constructed and operated on this purpose. From the case study of BedZED, it can be found that this live project demonstrates an innovative thinking for the intrinsic lifestyle change besides those integrated

technical measures. This sociological approach can be seen as another crucial perception for sustainability, which is important to close the design loop in the series of discussions for post occupancy evaluations (POEs). Thus, by identifying a case study with a post-occupancy perspective, the importance to enable ZEDlife has been brought forward as an alternative interface to enact zero emissions or zero energy development in China.

This paper addresses in particular the knowledge transfer between all stakeholders. Since the long-term energy consumption during the lifetime of a building is far more than the embodied energy consumed in construction period [1], the proper awareness and value judgement by residents, especially by those with no specialist knowledge, will play an important role to save energy and achieve sustainability. Hence, it is the designers' responsibility to communicate what lies behind design and how occupants can best use it. Some assistant media related to trans-disciplinary collaboration would be expected if necessary. And accordingly, an integrated socio-technical perspective will become the essential of all in the participative decision making process.

## 2. SUSTAINABILITY IN CHINA

As the world's most populous country where energy is mainly sourced from fossil fuels, China accounts for the second largest energy consumption in the world and holds a great responsibility for avoiding climate change. In the construction industry,

although the average energy use in buildings is proportionately lower than some western countries for historical reasons, the total energy requirement is significant in absolute terms. It is a large proportion according to the national total and has risen annually, from 27.8% in 1999 to a prospective 33% in 2020 [2]. Therefore, it is crucial for China to manufacture buildings with energy efficient features. Moreover, since the domestic sector of the economy always consumes more energy and resources than the commercial sector [3], sustainable design strategies for housing market development have been put to the forefront of this discussion.

However, since the definition of sustainability is contentious on either theoretical contents or executive guidelines [4], the evaluation of sustainable architecture is still in progress and there is no one model of planning, design and development that is supposed to be pursued above others [5]. Therefore, although there is often a general awareness of this topic and its relevant issues, the limited impact in China has been mainly concentrated on the academic approach. By comparison in practice, many professionals intend to fix sustainable features into design process by using their familiar measure – ‘technical response’ [4]. Until now these kind of tech-dependent solutions have been widely used, covering almost every aspect of the architectural research domain like lighting, ventilation, thermal insulation and so on. Nevertheless, the circumstance of applying these tech-dependent design strategies in the housing market of China is not optimistic.

The tech-dependent design strategies often result in a misunderstanding in perception and drive many architects to see the sustainable design approach as an evolution of ‘high-tech style’ in contemporary architecture. Technical measures, or sometimes just symbols for ‘high-tech’, have been put into schemes in the phase of brief design, even before the passive design strategies have been fully applied. They help less but increase the project budget as well as the cost per square area. In the housing market, therefore, sustainability has been seen as a label of ‘high-cost’ to developers and designers as well as ‘high-price’ to purchasers. And the appearance or representation of sustainable housing always get much more attention than the intrinsic meanings lying behind. For example, according to the resource circumstance in China, timber should not be taken as an ecological material for construction [6]. However, to please people and let the housing project look more ‘green and sustainable’, some new housing developments in Shanghai (one of the most important commercial and industrial cities in China) uses timber imported from Canada to make the housing facade look like ‘sustainable houses’ in western countries. Obviously, this strategy is for the market benefits yet some key concerns of sustainability, like the embodied energy for materials in this case, seem to be overridden or ignored in the rush to inclusiveness.

From the review and analysis above, several native characters have been defined as the main barriers to carry out sustainable design in the housing market of China. Firstly, because of misunderstanding, people’s inspiration for the ‘modern lifestyles’ of

western counterparts often leads to a way of living that yearns for high living standard at the expense of energy consumption as well as waste and pollution [7]. Following with this tendency, the eco-footprint in China will soon account for more than any western countries due to the size of population and the speed of urbanisation. Secondly, with less-developed technologies and less-trained local labour, energy in the construction industry has often been used in an inefficient way – the energy consumed to increase one GDP unit in China will cost three to nine times as much as some western countries [7]. In other words, although some experimental houses can be constructed with detailed technical considerations, it is difficult to achieve sustainability in the holistic market through a perspective focused on technical aspects only.

Therefore, the alleviation of these two conflicts and implementation of the intrinsic meanings of sustainability in the housing market of Chinese big cities, have become the main tasks.

### 3. ZERO EMISSION/ENERGY DEVELOPMENT

In the UK, the idea of Zero Emissions Development, or Zero Energy Development, has been existence for years and has often been known as its abbreviation – ZED. As a brief exponent of this concept, Bill Dunster has successfully represented this notion with a complete housing scheme at Beddington in London, the Beddington Zero Emissions and Zero Energy Development or the BedZED (Figure 1). It is also a joint initiative between the BioRegional and the Peabody Trust.

#### 3.1 BedZED

Located in the London Borough of Sutton, the Beddington Zero Emissions/Energy Development is a mixed-tenure, mixed-use ‘solar urban village’ which also includes some commercial units and community facilities. This scheme aims to enable people to live in a sustainable way without sacrificing ‘a modern, urban and mobile lifestyle’ [8]. Details of the design features for this scheme have been widely publicized and can be seen as an integration of social amenity, financial effectiveness and reduced environmental impact [1, 5]. And the main design measures have been summarized in the following:



Figure 1: BedZED, London

- Social aspect:
  - Mixed-use & mixed-development for tenure*
  - Living and working from home*
  - Outdoor private space for all properties*
  - Green transport plan: pedestrian first; bicycle storage*
  - Proximity to community facilities for local activity*
  - Local car pool*
  - Choice for an alternative carbon-free lifestyle*
- Economical aspect:
  - Affordable accommodation with high design quality*
  - Commands margin over market value*
  - High density plan to add development value*
  - Low energy running bills*
  - Low risk based on existing prototype: Hope House*
- Environmental aspect:
  - Zero fossil fuel and carbon neutral*
  - 100% renewable energy use: PV & Bio-fuelled CHP*
  - Zero heating by passive solar gain & high insulation*
  - Heat recovery ventilation systems powered by wind*
  - Low embodied energy materials: sourced locally*
  - Recycled materials – timber and steel*
  - Water recycling and water efficient appliances*
  - Waste recycling*

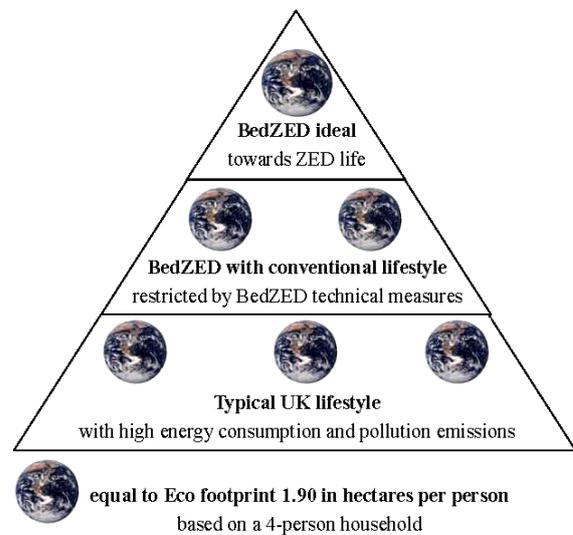
Towards sustainability, all these design measures have been integrated together positively in BedZED. As a result, this scheme was on the short-list for the Stirling Prize 2003 as the only residential project, which demonstrates its special value in the housing market. Although not all the sustainable features work properly during their later operational processes (for example, some problems are existing in the CHP and the water recycling systems), they have shown some good ideas. Moreover, compared with a typical UK family (based on a 4-person household) that is now consuming three times ecological resources than they should, people in BedZED have reduced their eco-footprints greatly by using the ZED's tech-dependent facilities, recycling their waste and having local food. However, Bill Dunster, the principal designer of BedZED, argues that people in BedZED would still need two planets to sustain their conventional daily lives, although the local residents' footprints have been restricted by the technical integration to a considerable extent. (As shown in Figure 2)

In other words, therefore, current technologies in the housing market can hardly satisfy the existing lifestyles. An essential change has to be made to achieve energy saving, carbon reduction and climate improvement – enabling people to adopt a ZED's lifestyle.

### 3.2 ZEDlife

Currently many people have realized that the existing lifestyles have become very stressful along with the increasing dislocated daily activities. Rather than just inconvenient, they sometimes feel uneasy about their future lives, particularly when thinking about the next generation. As described below,

*'...We are as a nation currently consuming enough resources to need 3 planets to survive – we only have one... we also know that a typical UK family's annual carbon emissions are approximately a third for heating and powering their home, a third for private car use, commuting and travel, and a third for foodmiles...'* [9]



**Figure 2:** Ecological footprints for UK lifestyle in hectares per person [Data source: 9]

Obviously, there is no point in producing energy efficient buildings if transport and foodmiles are not addressed. Hence in BedZED, a holistic and thorough approach to sustainable living has been designed for the future residents before the buildings, known as the 'ZEDlife'. Actually this alternative lifestyle doesn't require any intrinsic sacrifice to the future residents' existing lives; on the contrary, it demonstrates a more environmentally friendly living way where people 'don't spend a fortune on expensive cars – simply borrow one when need; use energy efficiently and reduce the unnecessary energy consumption; don't have to eat organic vegetable flown in from the other side of the world; etc.' [9]. To sustain a good quality of life for future generations, all the competing parameters which shape people's daily lives have been integrated from an architectural outset. In other words, towards sustainability, ZEDlife aims to force the residents to re-evaluate everything they do with a broader public purpose in mind. [1]

The strategy of enacting an alternative lifestyle is extremely important to implement sustainability in China. To this populous country, which is developing at a high speed but with relative less-developed technologies and less-trained local labour, the common consciousness of ZEDlife means more than any detailed technical add-ons. Moreover, Dunster also points out, although the building can be designed to encourage lifestyle changes, it is left to residents to decide how far they want to go to do this [9]. Thus, to a great extent, it is the residents' personal attentions that decide whether they would like to be part of the problems or the alternative solutions.

## 4. CLOSE THE LOOP

As an anthropocentric concept from its outset, ZEDlife has already put 'people' to the first and foremost position in this discussion. Likewise, to close the loop between design intentions and performance-in-use, the changes in people's 'attitudes', 'social

values' and 'inspirations' will become the essential of all, which will also highly depend on 'vast campaigns of education, debate, and public participation' [10].

#### 4.1 Post occupancy evaluation (POE)

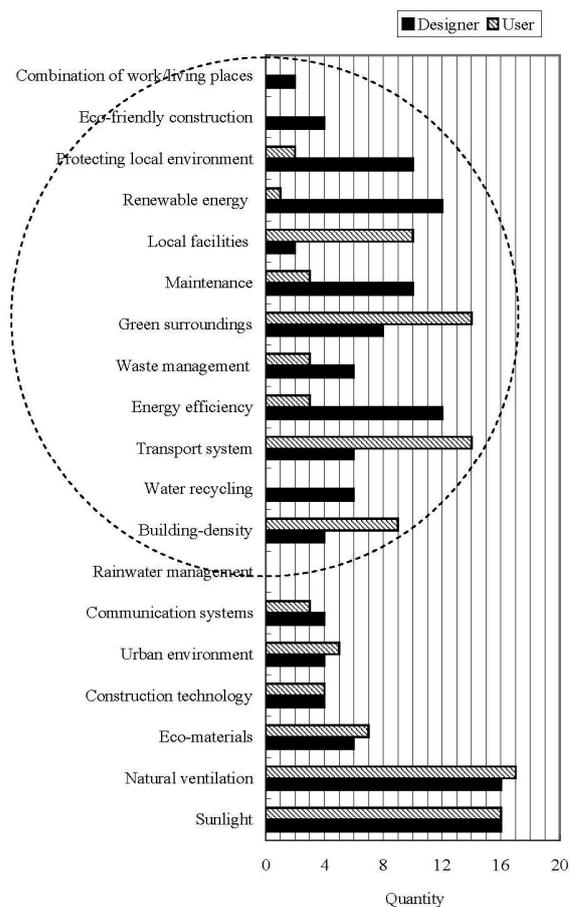
As Melet [11] points out, whether a building is really sustainable is 'something we can only determine retrospectively'. This is because the main energy consumption and pollution emissions from the construction industry have been concentrated on the building's operational phase [3, 12], while there are often 'significant differences' between the predicted, simulated performance of many new buildings during their design phase, and the actual consumption in their using or running process [13]. To close the loop, therefore, architects have been asked to re-evaluate their contributions more carefully, with the benefit of hindsight. The research activities for post-occupancy evaluation (POE) have been so established, and simultaneously a relevant discussion about this topic has also been raised up widely [14, 15].

In BedZED, although the lifestyle transition has been enabled on site, many post-occupancy monitors have been carried out to examine its performance in use and how much the residents would like to adapt their daily behaviours to fit in with the alternative lifestyle. As stated before, only when the residents adopt an intrinsic lifestyle change - ZEDlife, the local eco-footprint can be reduced to the ideal of ONE planet (see Figure 2). Thus, the essential success of BedZED will heavily rely on the occupants' proper 'consciousness' and 'awareness'. Moreover, unlike any commercial or office buildings where the relatively regular human activities can be possibly monitored by professionals or intelligent systems, residents (typically with no specialist knowledge) have gotten much more initiative when running their homes. This is also true in the housing markets of China – in order to achieve energy efficiency, carbon reduction and reduced environmental impact, the occupants will play an important role during the housing's post-occupancy process [14].

Therefore, to achieve an intrinsic Zero Emissions or Zero Energy Development, it is crucial that every stakeholder has been associated with each other in a positive way at the initial stage of design!

#### 4.2 Cognitive gap in knowledge transfer

As stated above, the decision-making process for sustainability can be seen as a knowledge transfer program where all the stakeholders' perspectives are supposed to be integrated together towards a united solution. In housing market, however, because of the widely differing backgrounds and intrinsic motives between different stakeholders, cognitive gaps always exist. Moreover, since the communication between designers and occupants is both indirect and weak, it always results in an increasing remoteness and makes the cognitive gap explicit. Thus it is believed that: this cognitive gap might lead to an unsatisfactory outcome during the operational phase of house occupation, unless the preferences of architects and occupants were identical or one of them would like to adjust their understanding according to the others'. [14]



**Figure 3:** Preference of main features for sustainable housing by Designers & Users: 'significant difference' for the issues in the dashed circle

To verify this hypothesis and see whether the preconditions could be achieved easily, an investigation has been carried out in the housing market of Shanghai. Although there are some agreements between designers and housing occupants, many significant differences for their central priorities exist, as shown in the dashed circle in Figure 3. In other words, although both of them have been required to change their attitudes towards sustainability, the designers' intentions for design measures don't match up with the occupants' attentions for daily lifestyles – their preferences are not identical. Since this difference is led by the cognitive gaps, it is believed that a similar situation also applies in the UK.

Therefore, to achieve a better outcome towards win-win sustainability, it is important to let one of the stakeholders adjust their understanding according to the others'. This will only happen when the message lying behind design can get across well, and accordingly the message itself must be understandable first.

#### 4.3 Get the message across

ZED design requires the residents to change their conventional lifestyles during the operational phase of house occupation and always keep awareness on energy use, carbon reduction and some other

relevant issues. Thus it will make no sense if these ultimate users are excluded from the decision making process. Lack of communication may result in misunderstanding, which then might breed distrust at times, for both designers and occupants in the decision making process. Moreover, because of this kind of communicational absence, the interrelationships between these stakeholders also tend to break down.

Therefore, it is the architects' responsibility to communicate what lies behind the sustainable housing design and how occupants can best use it. To get the message across, a more open participative design process is expected, not only designers and users should be involved but also other relevant stakeholders. Taking BedZED as an example, it can be found that this project came into being through the coordinated efforts of all participants, even the local authority. Peabody Trust and BioRegional (the co-developers of BedZED) got the tenure though they did not bid the highest price. Sutton Borough Council judged they could offer the best value to local development with their sustainability proposal although not all benefits of ZED development could be calculated. This is one of the first occasions that a UK local authority accepted sustainability benefits as additional value. And later it also got the approval of central government. [8] Moreover, to let the new occupants understand the lifestyle of ZEDlife better, many ZED-focused exhibitions and forums were used as communicational platforms after BedZED was occupied.

Nevertheless, it is not easy to achieve a kind of impartial participation as happened in BedZED. And it is also questionable what kind of protocol program should be raised up to help the participants reach a consensus of Zero Energy and Zero Emissions Development. In the housing markets of both UK and China, there is still a long way to go to make the message of ZEDlife more understandable and more marketable.

## 5. A SOCIO-TECHNICAL PERSPECTIVE

From the case study of BedZED and the relevant discourse about closing the loop, it can be found that the two approaches of sustainable housing design, technical potentials and their social context, are never supposed to be used alone. On the contrary, as two sides of a coin, they should supplement each other in the participative design process and together contribute to a synthesis with both sociological and technical perspectives used [16, 17].

Most of the early socio-technical studies have been related to certain types of policy instruments in order to develop an understandable language and conceptual framework to analyse processes of system-building, interactions between stakeholders in the networks, or controversies of relevant social groups [16]. The benefits will be bidirectional. To stakeholders with professional knowledge, these measures can help them to improve their understanding of the innovation of sustainable design, provide tools and concepts for analysis, inform

programmes to promote certain technologies and provide tools to evaluate them [16]. To stakeholders typically with no specialist knowledge, they would also feel more content when being required to change their daily behaviour towards sustainability since they have been involved in the decision making program in a positive way [16].

Among all these stakeholders, however, occupants of sustainable buildings, particularly those with no specialist knowledge, have often been at the forefront of this discourse [18]. Some trans-disciplinary research work and relevant modelling processes have been proposed towards this approach. For example, in a recent discussion about influences on domestic energy consumption, a Bayesian Belief Network model has been constructed as a 'landscape' to examine the knowledge synthesis across the social, economic and behavioural sciences [17]. As an assistant media, this stakeholder engaged, evidence based 'live model' is proposed to be widely applied in future to analyse the interdependent socio-technical influences on home energy consumption [17]. Moreover, this model will also help the housing design program be developed towards sustainability from a very start.

Further study is still ongoing and more research is expected, both experimental and experiential.

## 6. CONCLUSION

From the case study of BedZED, it can be found that current technologies in the housing market can hardly satisfy existing lifestyles. Since the energy consumption has been concentrated on the operational phase of house occupation, an essential lifestyle change by the occupants (typically with no specialist knowledge) has to be made to achieve energy efficiency, carbon reduction and climate improvement. In China, with larger population as well as relevant less-developed technologies and less-trained local labour, this situation becomes worse when people begin to aspire for the 'western modern lifestyle with high energy consumption'. Therefore, to achieve sustainability in the housing market, it is crucial to enact an alternative lifestyle towards a model such as ZEDlife before any detailed technical measures are added on. However, because of the widely differing backgrounds and motives, the preferences of architects and occupants are not identical – designers' intention and occupants' attention don't match up voluntarily. Thus, to achieve an ideal outcome, one of them has to adjust their understanding according to the other. The success of this interaction will depend heavily on how well the message about ZEDlife impacts on the decision making process.

Therefore, to close the loop, architects have been asked to adopt a socio-technical perspective in the participative design process. This alternative interface will help housing designers communicate with housing occupants, especially those with no specialist knowledge, about what lies behind design and how they can best use it. Some more relevant research towards this approach is expected to be carried out in

the future, but the principal finding also indicates that, though there is a general awareness of sustainability, that it has so far made only limited impact on people's lifestyle change. Therefore, there is a degree of untapped opportunity in the social interventions to influence human attitudes and behaviours towards sustainability. And the interrelationship between designers' and occupants' propensities for energy use, carbon reduction and climate change will become the first steps to explore.

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