

# Delivering sustainable communities: a case study in China

Delivering sustainable communities

253

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## Abstract

**Purpose** – China's accelerated urbanisation leads directly to pressure on the urban environment. The purpose of this paper is to identify best practices involved in a real sustainable community projects for the experience to be replicated in future.

**Design/methodology/approach** – To explore the practical development experiences and technological applications, a case study was conducted, involving both document analysis and semi-structured interviews.

**Findings** – The findings identify the green technologies and strategies used in the project planning and design process. The social considerations of the project development are also recognised in providing comfort, convenience and safety for their residents. Furthermore, the research highlights the fact that sustainable communities can incur less operational costs compared with traditional ones and therefore provide a feasible option for clients with a greater capability for upfront investment.

**Originality/value** – The results of the research provide valuable references for developers in the development of sustainable communities in both China and other countries.

**Keywords** China, Case study, Project development, Green building, Best practice, Sustainable community

**Paper type** Case study



## 1. Introduction

In recent years, China has witnessed rapid economic growth and urbanisation development. However, this has given rise to a number of environmental problems and challenges, such as pollution, energy consumption, ecological destruction and carbon

emissions (Zhang *et al.*, 2007; Li, 2010; Shen *et al.*, 2015), which are likely to become even more serious with the increasing trend of urbanisation.

With the emerging problems in the urban environment and society, the Chinese government has gradually recognised these issues since the early 2000s and promulgated sustainable urban development to modify the economic growth to an harmonisation of economic, environmental and social needs (Li, 2010; Yuan and Zuo, 2011; Zhao *et al.*, 2014). Sustainable urban development promotes the viability of cities and neighbourhoods with environmental constraints and increasing urban population (Luederitz *et al.*, 2013). The goal of analysis and evaluation of sustainable urban development is to improve the quality of life (Bentivegna *et al.*, 2002).

As the community is the basic unit of urban development as well as the unit of sustainability measurement, practical actions towards sustainability need to be taken at the community level where the needs, understanding, awareness and aspirations of the local people and authorities in relation to sustainable development have to be considered and implemented (Yuan *et al.*, 2003). There is the need for sustainable community development (SCD) to revitalise communities based on the consideration of cultural, geographical and local product issues, in addition to the physical hardware in community construction. It is necessary for a sustainable community to build the relationships and interactions between economic factors and other elements of natural environment and humanity issues such as housing, education, health, accessibility and arts (Hsueh and Yan, 2011).

Although a number of research outcomes have been reported in relation to the planning, design, construction, operation and social aspects of SCD, these are relatively recent phenomenon (Zuo *et al.*, 2012, 2014). Many project stakeholders find it challenging to deliver sustainable community as it requires integrated initiatives and solutions for ecological, social and economical sustainability, which beyond the capacity of any single organisation or community (Roseland, 2000; Dale and Newman, 2010). The research presented in this paper therefore aims to improve this situation by identifying the main options available for owners and practitioners pursuing SCD goals. This involves a case study of the “Linked Hybrid” project in Beijing, which adopted a series of green planning, design, energy efficiency technologies and sustainable construction techniques. The findings of the paper provide a valuable reference for developers and other stakeholders in the development of sustainable communities in China and beyond.

## 2. Literature review on SCD

A variety of definitions of sustainable communities have been proposed depending on the interests, needs and cultures of the different communities involved. Of these, the definition provided by the UK Government in the Communities Plan in 2003 is the most quoted and popular among researchers and practitioners, where sustainable communities are defined as “places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life. They are safe and inclusive, well planned, built and run and offer equality of opportunity and good services for all” (ODPM, 2003).

SCD is a melding of the fields of community development and sustainable development (Hamstead and Quinn, 2005). It takes into account the relationships and interactions between economic factors and other community elements such as natural environment and humanity issues, and aims to achieve an integration

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of the economic, social and environmental objectives. It employs a participatory, holistic and inclusive process to embark on major positive changes in communities through natural environmental restoration, local economic stabilisation, employment creation, poverty reduction, well-being improvement, people empowerment and increase of community control (Hamstead and Quinn, 2005; Hsueh and Yan, 2011).

Most existing research in SCD is policy driven, where the government shows an interest in sustainable communities extending beyond socio-political concerns. For example, Ko *et al.* (2012) and Pillai (2010) discuss the policy guidelines of the USA and Scotland, respectively in incorporating SCD principles into environmental policy-making processes and assess the ecological and financial benefits to communities. SCD in low-income or less-developed areas is also a major issue of concern for the government and much discussed by researchers. Typical research in this field includes the adoption of a basic development needs approach to promote community self-help and self-reliance in sustainable and integrated development (Asadi-Lari *et al.*, 2005); exploration of critical issues to be considered in developing sustainable low-income communities (Ha, 2008); and strategies and measures for the realistic implementation of environmental control and sustainability (Kamel and Asar, 2012).

The dominant theme of existing studies relating to SCD is process oriented, focusing on their planning, design and construction. A great deal of research in this area deals with the development of energy efficient sustainable communities. For example, Zhang *et al.* (2007) investigate technologies and strategies for the development of low-carbon cities in China. Similarly, Rae and Bradley (2012) explore and analyse the critical issues involved in relation to the development of energy autonomous with its own local energy generation, storage and distribution systems. To evaluate the effectiveness of low-carbon sustainable communities and compare their energy saving levels, Hsueh and Yan (2011) establish a multi-criteria evaluation model for energy efficient project selection and performance assessment. Clark and Woodrow (2007) suggest ways of developing systems of clean and renewable energy supply for communities through public-private partnerships.

In addition to a planning and engineering focus, some attention has also been placed on social dimensions – an equally challenging process in building a sustainable community (Newton *et al.*, 2012). Social aspect of sustainability has been largely overlooked in the construction context (Zuo *et al.*, 2012). It is believed that the effectiveness of technological solutions for sustainable communities depends on the psychological response of the end-users (Schweizer-Ries, 2008). Social cohesion within a neighbourhood is believed to be critical to the harmonious interactions and mutual support of residents, thus leading to the residents' life-satisfaction and social sustainability (Cheung and Leung, 2011). With the importance of community support being recognised, studies have also been carried out adopting a participatory approach to sustainable regeneration and community development (Greig *et al.*, 2004; Valencia-Sandoval *et al.*, 2010; Deakin, 2012).

Although existing researches have highlighted various critical issues in SCD, there is still a lack of knowledge concerning the real practices involved in the lifecycle development of a sustainable community and the most successful experiences for replication in future projects. Furthermore, the current research on SCD covers different size of communities, ranging from multiple cities to small residential quarters (Zhang *et al.*, 2013). Apparently, these require different technologies and strategies for SCD.

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Therefore, this paper aims to contribute to the real practices of SCD. In particular, in Mainland China, as the residential units/quarters are the most dominant living communities in an urban setting, and affect the everyday lives of the urban population, the scope of community in this research focuses on the residential unit/quarter level.

### 3. Research methodology

This paper is exploratory, aiming to identify possible best practices in SCD. It focuses on “what” questions, using observation, open-ended questions in interviews and/or focus groups (Sekaran, 2003). Based on the nature of the research questions, the research philology of pragmatism is adopted as it argues that either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question (Saunders *et al.*, 2006).

Selection of research methods, which mainly include experiments, surveys, action research, case studies and interviews, depends on research questions and objectives, the philosophical underpinnings, the extent of existing body of knowledge and the availability of time and resources (Saunders *et al.*, 2006). To explore the practical development experiences and technological applications involved in a sustainable community project, a case study was conducted on the “Linked Hybrid” in Beijing, China. According to Yin (2003), a case study focuses on something unique, and the unit of analysis can be individuals, organisations, institutions or neighbourhoods. The case study approach helps to highlight the success or challenges presented to a project (Neale *et al.*, 2006) and can also prove valuable in situations where existing knowledge is limited or when a deeper understanding of a real-life phenomenon is needed (Yin, 2003). Furthermore, as Molenaar *et al.* (2004) highlight, case studies are especially suitable where researchers lack control over the subjects being studied. This makes the case study method eminently suitable for investigating the development of sustainable communities.

The case study is of “Linked Hybrid”, a SCD in Beijing, China, that achieved a high standard of environmental design and won a number of awards such as the Best Tall Building Overall Award by the Council on Tall Buildings and Urban Habitat in 2009. The study involved both document analysis and semi-structured interviews. The document analysis was conducted on project information sheets, reports and the results of a survey of the residents, provided by the developer. Online project information (e.g. site plan, floor plan, etc.) from public websites, mainly provided by Steven Holl Architects (the principle designer), was also thoroughly analysed. The interviews on the other hand were conducted with key practitioners involved in the project. These included the general manager and project manager of the head contractor, the mechanical manager, the heating/cooling system manager and the manager of the ground source heat pump system. Each interview took around one hour, starting with a brief introduction of the background of the study followed by a set of main questions:

- How does Linked Hybrid provide energy efficiency?
- How does Linked Hybrid provide social-friendliness?
- What are the specific difficulties involved in providing a sustainable community in China?
- What inspiration does the project provide for future sustainable community projects?

## 4. Case study

### 4.1 Background

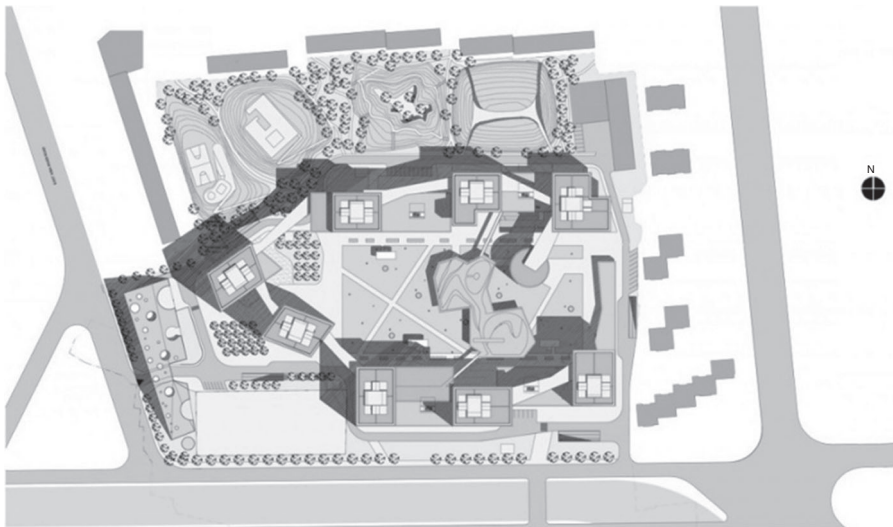
Based on the concept of a sustainable community, Linked Hybrid was developed by the Modern Green Development Co., Ltd Beijing, with Steven Holl Architects (USA) as the principal designer and Beijing Construction Engineering Group the general construction contractor from 2003 to 2009. The total project area is approximately 220,000 m<sup>2</sup>, and includes 644 apartments, public green spaces, hotel and public facilities (Figure 1). The community consists of eight linked buildings, with each building having an independent entrance to adjacent buildings. The centre of the buildings contains an open-air space that is accessible to all residents. By providing integrated and comprehensive facilities in an “open city within a city” theme, this project was expected to provide residents with an enjoyable experience and help relieve their life stresses.

### 4.2 Project planning

Since a community is a complex system of humans and natural environment, it is necessary for the stakeholders to plan for it from a comprehensive and systematic viewpoint (Chan and Huang, 2004). In addition to a sound physical environment which is usually considered in a green building planning, a sustainable community requires an integrated planning for the economic, environmental and social issues related to the community development, and ongoing maintenance in the long term.

The main purpose of this project planning is to understand the objectives of the client and search for potential solutions. During this stage, clients can convey what they want to the designers but cannot provide performance specifications, such as the amount of energy saving needed. To address this issue, the project manager undertook the following range of activities at the beginning of this project:

- understand the needs of the client;
- define the project goals with the client;



Source: Linked Hybrid/Steven Holl Architects (2009)

**Figure 1.**  
Linked Hybrid's  
linked buildings

- search for prior comparable cases for references;
- list possible scenarios for the project outcomes;
- search for possible solutions/proposals for the different scenarios;
- identify the most suitable scenario and proposal with the client; and
- document the details of the project.

Due to a lack of similar cases, it was difficult to find benchmarks for making comparisons. As a result, the designers had to simulate appropriate scenarios to help the client define the project goals.

The designers also searched for a number of reliable and new technologies that could be integrated into different scenarios to serve the project objectives. Next, feasibility reports for the different scenarios were presented to the client. These included the basic project requirements and associated forecast outcomes and risks to inform the client of the direct effects of the scenarios. The client then chose the scenario that provided the best fit with the company goals.

The project manager provided detailed information (e.g. budget and schedule) relating to these scenarios for the client's evaluation. Additionally, as the client lacked experience with sustainable community projects, the project manager at the planning stage mainly focused on facilitating the whole system design (WSD) and refining the client's demands to reduce project uncertainty.

Large-scale SCDs face more uncertainties than other types of projects, making the use of sustainable technologies in individual systems not necessarily appropriate. The WSD approach is a "process through which the inter-connections between subsystems and systems are actively considered, and solutions are sought that address multiple problems via one and the same solution" (Stasinopoulos *et al.*, 2009). Through the application of design-for-environment and design-for-sustainability strategies, WSD can assist with achieving sustainable development by enabling economic growth to be decoupled from environmental pressure. In this case, the designers had to consider the overall effect of adding sustainable technology to the system, and the costs involved in their procurement and use. Specifically, the designers mainly focused on optimising the sequence of the whole system and subsystems. After considering the project environment, financial situation and WSD, several available cutting-edge technologies were discarded due to their expense and instability. The designers also prioritised the available technologies according to their expected contribution to the desired functioning of the system.

The client's requirements at the early stage of the project were very ambiguous. The client's main concern was centred on the expenditure and financial returns involved and the range of costs of the sustainable technologies was very wide. Therefore, in order to meet the needs of the client and facilitate the decision-making process, the project manager and designers provided a final analysis for selecting the appropriate sustainability technologies to use. Table I provides an example of this in terms of the payback time for the ground source heat pump.

#### 4.3 Sustainable design

When designing a sustainable community, it is necessary to consider the social, ecological and economic factors involved. More specifically, with a reasonable project budget, the goal is to provide an enjoyable living environment for residents while

reducing pressure on the natural environment as much as possible. In particular, efficiently improving social communication is one of the most important objectives in obtaining a sustainable community (Taylor, 1998).

In designing Linked Hybrid, the architect Steven Holl resolved to remain within the urban context and persuaded the developer to expand its programme from being purely residential to one of mixed use containing a multiplex and hotel to attract non-residents. The project advocates the creation of a vibrant environment through the combination of interesting aesthetics, sustainability, technology and the exploratory development of urban interactive spaces. Linked Hybrid’s communicative attitude is expressed in the form generated by the towers and sky-loop, creating a permeable interface between the central plaza and its surrounds.

The social impact of the project design was an important consideration at the design stage of the project, with a focus on the comfort, convenience and safety of the residents of the community in order to have a better living environment. The design of the social areas was an essential feature for this community, as it facilitates daily working, communication, entertainment and shopping activities (Figure 2). This involved a particular focus on the reduction of travel time, as these daily activities are linked by transportation and is especially important in Beijing with its heavy vehicular traffic.

The facilities in the community include a sports club, health SPA, coffee house/bar, bookshop and art exhibition, which are located at levels 12-18 of the eight towers. At the first level, residents have access to the hotel, cinema, school, child-care centre and restaurant. At the centre of the community, there is a garden with a pond. These facilities meet the most of needs of residents without the necessity for external transportation as the towers are linked together through elevated pedestrian corridors.

Access to the outside of the community was another concern of the designers. ID verification and monitoring facilities are located at the three entrances to the community. All vehicles entering and exiting the community have to travel through an underground garage, within which elevators are provided for direct access to each unit.

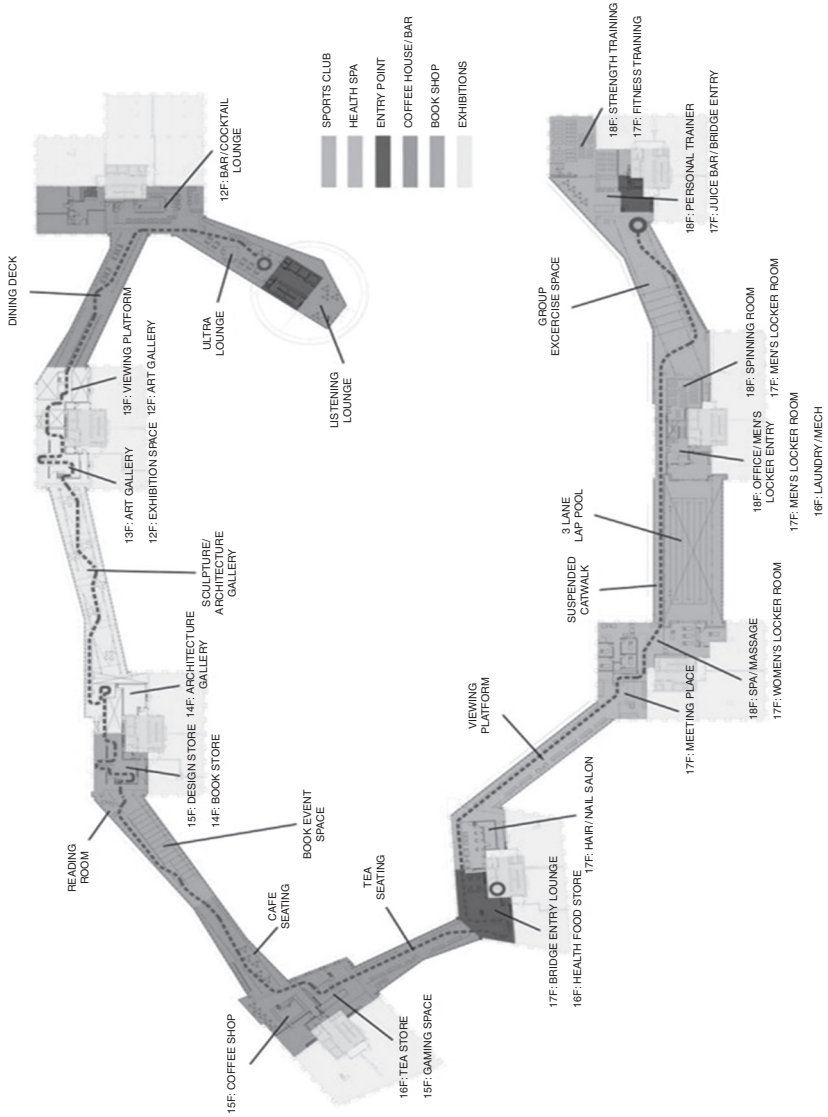
#### 4.4 Sustainable technologies

A number of green building technologies are utilised in Linked Hybrid, including:

- a ground source heat pump system: to distribute underground geothermal energy throughout the facilities;
- a solar power system;
- a water recycling system;
- a rain water recycling system;
- the use sustainable materials for easy recycling;

Technologies	Initial investment	Operation and maintenance fee p.a.	Comparison		Return years
			Investment	Operation and maintenance fee p.a.	
Ground source heat pump	31,000,000	5,240,000	13,500,000	-1,500,000	9
Traditional system	17,500,000	6,730,000			

**Table I.** Payback time for the ground source heat pump system



Source: Linked Hybrid/Steven Holl Architects (2009)

Figure 2.  
Social facilities of  
Linked Hybrid



- a ceiling radiation system: using solar energy to heat water to adjust room temperature;
- a displacement ventilation system: using outside air to adjust room temperature and provide fresh air;
- a noise reduction system;
- an external thermal insulation system; and
- an energy efficient façade and window system: to reduce heat exchange and radiance.

These technologies have been widely used in new green building construction projects, but very few projects apply all these technologies at once, making Linked Hybrid one of the largest green residential community projects in the world. The successful application of these technologies was realised through a careful assessment of their practicability and reliability in being used together in this way. In doing this, the designers considered the cost effectiveness and social impact of the technologies on the project as well their feasibility and ecological advantages.

The main green building technology applied is the unique heating/cooling system, which provides great energy efficiency. This comprises the three integrated core subsystems of ground source heat pump, ceiling radiation and displacement ventilation. These, together with the energy efficient facade and window system, are described in more detail in the following sections.

*4.4.1 Ground source heat pump system.* The ground source heat pump system utilises energy from underground to maintain room temperature instead of electricity or fossil fuel. This system contains three parts: a ground heat exchanger, pump system and heat distribution system. The pump is electrical and creates sufficient pressure to circulate water in a looped distribution pipe within the building. As the water circulates, it absorbs or releases heat into the building. Another pipe is connected to the underground ground heat exchanger and performs the opposite task. In this way, the system can maintain room temperature and improve indoor climate by using only a small amount of electricity (Mustafa Omer, 2008).

*4.4.2 Ceiling radiation system.* The ceiling radiation system helps adjust room temperature by water pipes laid in the ceiling in the form of a radiator. Both heated and cooled water can be directed through the pipes, so the system is used for both heating and cooling. In winter, the temperature of the water entering the room is maintained at 28°C, with the temperature of the water exiting the room being usually around 26°C. In summer, the entering and exiting temperatures are 20 and 22°C, respectively. Because of the layout of the water pipes, the temperature of the room can be evenly controlled – contributing to the provision of a stable year-round indoor temperature (Dieckmann *et al.*, 2004).

*4.4.3 Displacement ventilation system.* A displacement ventilation system is used to help control the humidity and freshness of room air. With traditional buildings, the occupants use either windows or air-conditioning to control room ventilation. Opening windows allows the ingress of fresh air, but affects indoor temperature. Air-conditioning, on the other hand, has the advantage of maintaining room temperature, but is limited in its ability to freshen air. To solve these problems, the intakes and outlets of the displacement ventilation system are distributed separately. The intakes and outlets are built into the floor and ceiling, respectively in order to provide efficient ventilation. In addition, the separation of the intakes and outlets prevents the exiting air returning into the room again (Hamilton *et al.*, 2004).

*4.4.4 Energy efficient façade and window system.* The facade is constructed of aluminium panels, which are both recyclable and have a pleasant appearance. To help maintain stable indoor temperature and humidity, the walls are multi-layered, with an insulation layer provided by 100 mm XPS plates, a moisture barrier layer of Tyvek House Wrap and a 97 mm air layer to reduce heat exchange between the building and outside environment. With this arrangement, the thermal conductivity of the wall is less than  $0.35 \text{ W m}^{-1} \text{ K}^{-1}$ .

Windows are the most important means of heat exchange between the indoor and outdoor environments and Linked Hybrid uses Low-E glass. This reduces the radiance rate from 0.84 to  $0.04\sim 0.12 \text{ W m}^{-2} \text{ sr}^{-1}$  and helps retain indoor heat in winter. External shading is used in midsummer to prevent solar heat gain, with an estimated reduction of energy use for cooling of approximately 83~88 per cent.

*4.5 Resident survey*

The green features of the project are well liked by the residents. In a recent survey conducted by the developer with 230 householders out of the whole 630 households (shown in Table II),

Items	Degree of comfort	Result ( % )
<i>Indoor temperature</i>		
Temperature in summer	Comfortable	96.5
	Cold	3.5
	Hot	0
Temperature in winter	Comfortable	86.1
	Hot	12.9
	Cold	1
The freshness of air	Fresh	81.7
	Relatively fresh	17.3
	Not fresh	1
The strength of the wind from displacement ventilation system	Cannot feel	91.7
	Can feel little	7.3
	Strong	1
The air humidity	Comfortable	83
	Dry	9.8
	Wet	7.2
<i>Sealed</i>		
Sealed	Good	93
	Relatively good	7
	Bad	0
Dust	Little	90
	A little bit	9
	Too much	1
<i>Sun shading</i>		
Use of the sunshade blinds in summer	Frequently	67.8
	sometimes	30.2
	seldom	2
Effectiveness of sunshade blinds	Good	87.2
	Relatively good	10.8
	Bad	2

**Table II.** Resident review of the comfort of the indoor environment

**Source:** Modern Green Development Co., Ltd Beijing

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an average of 88 per cent of the surveyed residents provided positive feedback on indoor and outdoor environment issues, including temperature, air freshness and humidity, wind strength, dust, etc.

## 5. Discussion

Linked Hybrid demonstrates best practice of SCD through project planning, design, integrated technologies and environmental-friendly systems that bring comfort, convenience and safety to the residents and financial benefits to the community stakeholders.

The planning stage of the Linked Hybrid features a close collaboration between the client, project manager and designer to detail the project plan and facilitate decision making. According to Berke and Conroy (2001), planning plays a critical role in promoting the dialogue about sustainability and in conceiving concrete public policy solutions that promote community sustainability. Integrated planning for the environmental, social and economic issues is performed to meet the client's requirement and ensure the community can be operated and maintained in a sustainable way in the long term. The development scenario is determined through evaluation and comparison of different proposals in terms of advantages, risks, budget and schedule. This ensures the most feasible scenario can be established to fulfil the function of the sustainable community within reasonable budget. As WSD approach offers designers the opportunity to holistically optimise solutions for social, environmental and economic sustainability (Blizzard and Klotz, 2012), the application of the WSD approach in this case enables designers to consider the overall function and possible uncertainties of sustainable technologies and systems to optimise the stability and cost effectiveness.

The social aspect of sustainability has gained increasing importance in the SCD (Bramley and Power, 2009; Dempsey *et al.*, 2011). In this case, the social dimension is extensively considered in the sustainable design of the project to create a quality and vibrant living environment for the residents. In addition to a residential place, the design of the community enables people's communication and interaction and provides the residents with convenience through various facilities and technological innovation. Both aesthetic and sustainable performance of the community is considered in design. The community is also well connected with the Beijing city while security is highly regarded and maintained.

By providing a number of green building technologies, the designers made every effort to reduce project costs and maximise the financial benefit for the client. A pre-evaluation survey was made of all possible cutting-edge technologies and the most expensive and unstable were removed from consideration. The feasible technologies remaining were further assessed for their compatibility and only those capable of being integrated together were selected. In addition, the designers also focused on the optimisation of the integrated technologies to further improve their function and minimisation of costs. The total investment of the project is 48 million RMB and with an estimated payback period of nine years.

It is also worth noting that the green systems used have provided substantial cost savings for the client and residents. The total annual operating expenditure of the heating/cooling system, for example, is approximately five million RMB or 23.4 RMB/m<sup>2</sup>, with a resident's fee of 7.1 and 8.3 RMB/m<sup>2</sup> in winter and summer, respectively. In comparison, a traditional heating/cooling system has an expected six million RMB minimum or 30.1 RMB/m<sup>2</sup>, with resident's fee of 9.1 and 11.1 RMB/m<sup>2</sup> in winter and summer. Therefore, although the green technologies demand a significant initial investment, their long-term financial advantages enable them to be viable options for clients as well as being the financial and well-being choice of the residents.

## 6. Conclusions

This paper provides the findings of a case study of a sustainable community, Linked Hybrid, in China to identify the best practices for developing such a community. The planning and design processes and sustainable technological applications are presented with discussions on environmental, social and economic issues involved. As evidenced by the substantial cost savings for the client and residents and the positive feedback from the resident review of the comfort of the indoor environment, these environmentally friendly features incorporated in the project development process have achieved satisfactory sustainable performance.

However, it should be noted that the performance of social sustainability of this project needs further investigation. Additionally, as with any single case study analysis, it has a number of limitations such as researcher subjectivity, and the likely lack of external validity. Extra care should be paid when applying the findings from this study for other community development.

Nevertheless, the planning and design processes of the project's green systems provide useful practical implications for future SCD. The feasibility studies, decision-making process and adaptable redesign of the technological scenario are necessary for project success and cost efficiency. In particular, the Linked Hybrid development team paid great attention to the residents' comfort, convenience and safety. The private spaces, social areas and access to outside the community were all designed to provide a better living environment for the residents. The case study also demonstrated that, although the green technologies used required a large initial investment, the annual operating costs and resident maintenance fees in the long term are much lower than those of traditional building systems, making SCD in this case a viable proposition for clients with a higher financial capability.

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### Further reading

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