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Clients' Role in Attainment of Sustainability in Housing: The Case of Singapore and Lessons for Developing Countries[1]

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Abstract: The adverse effect of the construction of houses and other buildings and infrastructure on the earth's environment has been highlighted in the literature. Proposals on how the planning, designing, constructing and maintaining of residential units can be undertaken under the framework of "sustainable development" (or "sustainable housing") have also been made. Housing units built in this way would have less environmental impact. Housing is a basic human need, and most governments are committed to ensuring that all their citizens have decent standards of housing. There are currently gaps between needs and provisions in almost all countries. Large volumes of resources will be required if these gaps are to be filled. There will also be other environmental impacts from such levels of activity. This paper discusses recent developments in sustainable housing. It focuses on the role of the client. It reviews the current situation with respect to sustainable housing in Singapore, putting it in the context of the national policies and programmes for sustainable development. It discusses the practices of the larger clients of housing developments in Singapore. Possible lessons for other countries are inferred. It is suggested that further education of the client is necessary. Moreover, there is the potential for end purchasers to be similarly educated, in order to form them as a market force for change.

Keywords: Housing needs, National policies, Environmental sustainability, Clients, Singapore, Lessons

INTRODUCTION

Aim and Objectives of Paper

The aim of the paper is to consider the role which clients can play in the efforts to attain sustainability in the planning, design, construction and maintenance of housing units. It uses recent developments in these regards in Singapore to offer and assess possible ways by which progress can be made in developing countries.

The objectives of the paper are to:

1. Consider the literature on sustainable housing and its relevant aspects including how it can best be achieved, its benefits and the challenges it poses.

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2. Discuss developments in housing and sustainable development in Singapore and actions by corporate clients to attain sustainable housing by ensuring better performance of the industry which creates the houses.

3. Propose possible actions which will contribute to the efforts to attain sustainable housing, focusing on the role of the client.

The paper starts by considering the broad concept of "sustainable development". It then covers "sustainable housing". The situation in Singapore with regard to sustainable development and sustainable housing is discussed. Some recommendations are then made.

REVIEW OF PAST WORKS

Sustainable Development

Since early 1990s, there has been a consensus on the need for all human activities to be undertaken with due consideration of the need to safeguard the quality of life of both the present and future generations. There are many definitions of "sustainable development". It is useful to consider the definition suggested by a statutory agency in Hong Kong (Planning Department and Environmental Resources Management, 2000b):

> Sustainable development in Hong Kong balances social, economic and environmental needs, both for present and future generations, simultaneously achieving a vibrant economy, social progress and better environmental quality, locally, nationally and internationally, through the efforts of the community and the Government.

The definition considers what is to be done, the purpose of this action, and the actors. Sustainable development has several aspects. For example, the Hong Kong government adopted the following "guiding principles" of sustainability (Planning Department and Environmental Resources Management (2000a): economy; health and hygiene; natural resources; social; biodiversity; cultural vibrancy; environmental quality; and mobility. Chan and Yung (2004) use these following "sustainable development criteria" to analyse the development control framework (for housing and other buildings) in Hong Kong.

This paper discusses sustainable development in the context of the planning, design, construction and maintenance of housing units, or "sustainable housing". It focuses on the environmental aspects of sustainability. It is an important aspect where housing is concerned. For

example, Ofori (1992) argued that "the environment" should be the fourth client objective on construction projects (after cost, time and quality). In recent years, the environment, and health and safety have become quite established as desirable construction project objectives.

Housing and the Environment

It is necessary to define "the environment" in the context of the housing development process. Ofori (1992) suggests that the scope of "the environment" in the context of the construction industry is: (i) resource conservation, (ii) prevention of all types of pollution, (iii) protection and preservation of natural ecosystems, (iv) safeguarding the fabric of constructed facilities in changing atmospheric conditions, (v) promotion of the health and well-being of users of the built facilities, and (vi) development of environmentally-conscious lifestyles of the users. The following can be added: (i) preservation of land, (ii) protection of the health and safety of the workers and occupants of nearby buildings, and (iii) support of environmentally conscious production by purchasers and users. A "sustainable housing" unit would meet these criteria.

Housing development, as with all forms of construction activity, is considered in the literature to pose a variety of environmental problems. Chen et al. (2005) highlight the following environmental challenges from the fast pace, massive volume and intensity of the development of new housing estates in Beijing, China: inefficient land use, water shortage, air pollution, traffic congestion, deterioration of the ecological system, high energy consumption, and high volumes of waste to be managed.

The solutions to the impact of housing development on the environment include: undertaking environmental impact assessments on sites to find mitigation measures against the potential negative effects, designing for energy efficiency, and choice of appropriate materials (Chau et al., 2005). Some of the possible solutions are quite simple. For example, a balcony is considered to contribute to reducing noise pollution by acting as a traffic noise barrier. Wong and Yu (2005) found that plants within developments can cool the surroundings and generate lower ambient temperature; there was a strong correlation between decrease in temperature and the appearance of large green areas in the city.

Chan and Yung (2004) suggest that "sustainable dense urban development" should have these features: (i) provide adequate housing, (ii) provide quality living space, (iii) provide adequate open spaces with a healthy environment, develop a centralized, self-contained urban city where the population is well served by public transport

systems (ensuring minimum travel distances to activities such as work, entertainment and education), (iv) enhance cultural vibrancy by preserving archaeological, historical and architectural assets and integrate them into the fabric of the city to provide a continuation of history, (v) develop a city environment with adequate daylighting, air flow and vistas, and (vi) respect the characteristics of localities.

However, in many countries, not much has been achieved at the broad level in the efforts to attain sustainable housing. The CIB and UNEP (2002) highlight the following barriers to efforts to realize sustainable construction in developing nations: (i) lack of capacity of the construction sector to implement sustainable principles, (ii) an uncertain economic environment and weak government finances, (iii) poverty, high demographic growth and low urban investment, (iv) declining government investment in construction, (v) lack of accurate data on environmentally responsible materials, equipment and methods, (vi) lack of interest in sustainability issues among stakeholders, (vii) technological inertia, and (viii) lack of research on relevant subjects.

The literature highlights the benefits of environmentally conscious development to clients and users. These include: compliance with regulations, savings in operating costs of the buildings including lower consumption of energy and water, improved indoor environmental quality, leading to better health and productivity of occupiers, avoidance of liability claims, including on indoor air quality, direct response to increasing consumer demands for environmentally responsible products, and accordance with clients' and designers' altruism, and social and professional responsibility (Spiegel and Meadows, 1999; RICS, 2005). Chau et al. (2005) note that sustainable housing units cost less to run, have less adverse impacts on the health of their occupants, are more valuable to their owners, and are more socially responsible.

Seabrooke et al. (2004) note that two main views must be reconciled. Whereas it is widely held that the full cost of mitigating unavoidable impacts should be borne by the developer, the latter often argue that social and environmental costs should be borne by society and met from tax revenues, and that society may minimize social and environmental costs through development control. Governments apply a combination of regulations and economic instruments to encourage businesses and individuals to take actions that will protect and enhance the environment. Chau et al. (2005) note that some governments provide incentives to developers to introduce environmentally responsible features in their buildings. For example, in Hong Kong, the following are excluded from the calculation of gross floor area for development control purposes: balconies, wider common corridors and lift

lobbies, communal sky or podium gardens, sunshades and reflectors; and acoustic fins.

It has been noted that development statutes and building codes may be among the obstacles to the efforts to attain sustainable housing. Chan and Yung (2004) argued that many of such laws in Hong Kong were not conducive to meeting the requirements of sustainability. These include: the general control mechanism, zoning-statutory plans, density control – plot ratio and size coverage, planning control – urban design guide plans and planning application, lease modification, building control – regulations, open space, prescribed windows, and environmental control. Chen et al. (2005) suggest the following actions to improve planning and design practices: integrated land use, improved infrastructure planning, enforcement of building codes, energy consumption measures, cooperation among stakeholders, and public participation. Steinberg and Miranda (2005) also found merit and benefit in cooperation among stakeholders to manage environmental issues in cities in Peru, through coalitions of municipalities, universities, non-governmental organizations, the private sector and civil society. They urge continuing training, educational services and technical assistance to facilitate this process.

In the next section, the situation in Singapore is considered. First, the efforts to attain sustainable development are discussed. This is followed by consideration of sustainability in housing, considering the national institutional framework, and then the actions of clients.

SITUATION IN SINGAPORE

Sustainability in Singapore

Institutional framework and action plan

Singapore has a good record in sustainable development efforts. There is a comprehensive body of statutes, regulations and codes which govern activities, outline good practice, provide norms and targets, prohibit harmful actions and products, and set sanctions. These include the Environmental Pollution Control Act and the State Lands Encroachments Act. There is also an institutional framework for formulating, implementing and enforcing policies.

The National Environment Agency (NEA) was formed under the Ministry of the Environment and Water Resources (MEWR) in 2002 to formulate and implement measures to ensure a quality environment for Singaporeans. The NEA implements programmes to monitor, reduce and prevent environmental pollution. To conserve energy resources and landfill space, it

implements programmes to minimize waste generation, and maximize recycling and energy conservation. It also undertakes ground surveillance and preventive measures to enhance public health. The vision of the NEA is: "An enterprising agency, embracing all in caring for our clean and healthy environment – today, for tomorrow." Its mission is: "To ensure a sustainable quality environment in Singapore." The NEA seeks to accomplish this by working in partnership with the community through: facilitating and providing excellent environmental services, promoting environment-related industries, and training and public education.

The framework for action to attain sustainable development in Singapore is the national Green Plan, first published in 1992. The latest edition, the Singapore Green Plan 2012 (Ministry of the Environment and Water Resources, 2006), covers the following focus areas: (i) air and climate change, (ii) water, (iii) waste management, (iv) nature, (v) public health, and (vi) international environmental relations. The following new targets were added after the 2006 review in which over 17,000 people participated:

1. Reduce the ambient Particulate Matter 2.5 level to within an average of 15 µg/Nm^3 by 2014.

2. Improve carbon intensity (i.e. carbon dioxide emission per GDP dollar) by 25% from 1990 level by 2012.

3. Reduce Singapore's per capita domestic water consumption from 162 litres per day in 2004 to 155 litres per day by 2012.

4. Partner the people, private and public sectors to generate greater awareness of the importance of conserving, valuing and enjoying water and develop a sense of shared ownership of our water resources.

Two aspects of SGP2012 which are particularly relevant to housing are: "clean land" and "clean air". To ensure clean land, it is necessary to manage waste effectively. This is pertinent here as construction and demolition wastes constitute a high proportion of the total amount of waste generated in most countries. To reduce the volume of waste generated in Singapore, SGP2012 proposes: volume reduction by incineration, waste recycling, reducing landfilled waste, and waste minimization. It notes that about 90% of the waste is incinerated The non-incinerable, waste includes concrete slabs, bulky materials and incineration ashes; these are landfilled. The plan aims to achieve "Zero Landfill". It proposes more recycling efforts such as the National Recycling Programme (introduced in 2001), and encouragement of consumers and producers to minimize

the waste generated. The waste management industry will be liberalized, the efficiency of the waste incineration sector will be increased, and the economic cost of waste disposal will be reflected in the rates. The recycling industry will be developed, and Singapore positioned as a centre for recycling technology. Much has been done in these regards. For example, incentives and support, including access to land, have been extended to some waste management companies to undertake the recycling of construction waste.

Clean air is also pertinent to housing, because of the dust which building activities generate, and the energy intensity of the operation of buildings in Singapore. The country has maintained a high standard of air quality by setting stringent emission standards, promoting energy efficiency, and using energy sources that emit less pollutants such as natural gas. The concentrations of major air pollutants (sulphur dioxide, nitrogen oxides, carbon monoxide, ozone and PM below 10 microns) are below the levels set by the World Health Organization. However, new threats to clean air have been found. For example, PM smaller than 2.5 microns has been linked to respiratory effects such as bronchitis and asthma. The proposals include: (i) introduce a framework, programmes and policies to control the emission of air pollutants, (ii) leverage on regional cooperation in the control of haze, (iii) focus on targeted sectors to promote energy conservation and the use of cleaner energy sources such as natural gas, fuel cells and solar cells, (iv) encourage industries to implement effective air pollution control measures, and (v) explore and test-bed new technologies that Singapore can adopt.

Some other initiatives of environmental sustainability relevant to housing

In Singapore, planning for the use of land, coast and the sea is undertaken in an integrated manner. The Urban Redevelopment Authority works with the National Parks Board to assess the environmental impact of development projects and institute measures to minimize adverse impacts. Critical zones, such as those with delicate ecosystems, are protected. Examples are the key coastal and inter-tidal ecosystems at Labrador and Sungai Buloh which have been gazetted as Nature Reserves, and Sisters' Island which has been identified as a marine nature area. The National Parks Board collaborates with the academic institutions and non-governmental organizations to monitor the biodiversity and health of the ecosystems.

Another key recent concept in Singapore relevant to sustainable housing is Skyrise Greening. The green roof has gained acceptance in North America, Japan and parts of Europe. It is reported that about 14% of the total flat roof surface in Germany has been installed with green roofs

(Lim, 2005). Considering the dense built-up environment, there is potential for green roofs in Singapore. Various agencies have contributed to the implementation of the concept. The Urban Redevelopment Authority has reviewed its guidelines on sky terraces to provide developers with additional gross floor area, giving them an incentive to help offset the cost of constructing sky terraces. Following a pilot Green Roof Project on the rooftop of a multi-storey carpark in a housing estate, the HDB has implemented rooftop gardens in many public housing projects, and the private sector has followed suit.

Environmental sustainability and construction in Singapore: Rules, regulations, benchmarks

Since early 1990s, there have been efforts to guide and control building activities in Singapore in order to reduce their impact on the environment. Apart from provisions in the building regulations such as the long standing one setting a mandatory norm for the overall thermal transmittance value of building facades, there are those made under the main statutory instruments, such as the Environmental Pollution Control Act, but which solely govern construction. For example, to ensure that construction sites in Singapore are free from environmental hazards which would affect the workers and residents near the sites, under Section 62 of the Environmental Public Health Act (Chapter 95), and the Environmental Public Health (Employment of Environmental Control Officers) Order 1999, the occupier of the construction site shall employ a competent person to act as an Environmental Control Officer (with stated necessary qualifications and training) on a full-time basis if the contract sum of the construction project is $50 million or more. For projects with contract sum between $10 million and $50 million, the Environmental Control Officer shall be employed on a part-time basis (to spend at least 15 hours per week supervising and promoting environmental public health on the site).

There are also non-mandatory regulations for construction organizations. Contractors wishing to undertake public-sector projects are required to register with the Building and Construction Authority (BCA) (which is responsible for the development of the construction industry). The criteria for registration for large and medium-sized firms include certification to the ISO 9001 quality management system (since 1999), ISO 14001 environmental management system (since 2004) and ISO 18000 health and safety management systems. Thus, each of the significantly-sized construction firms in Singapore has a management system for ensuring that its activities are not in conflict with the protection of the environment.

After a building is completed, it is necessary to determine the extent to which it meets the desirable environmental criteria. Many environmental assessment

and rating schemes are in use in various countries (Larsson, 1998). They include BREEAM (http://www.breeam.org) which was developed in the UK, and assesses the performance of buildings with respect to: (i) management, (ii) energy use, (iii) health and well-being, and (iv) pollution, transport, land use, ecology, materials (including life-cycle impacts), water. The US version is the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, which was created to: (i) define "green building" by establishing a common standard of measurement, (ii) promote integrated, whole-building design practices, (iii) stimulate green competition, (iv) raise consumer awareness of green building benefits, and (v) transform the building market. After studying a range of such schemes, the BCA launched the Green Mark for Buildings Scheme (Green Mark) in January 2005. The aim was: "To move Singapore's building and construction industry towards environment-friendly buildings and help strengthen Singapore's position as a global city committed to balancing its development with care for the environment" (Foo, 2005). The objectives of Green Mark are to: (i) promote environmental sustainability in the construction industry and raise the awareness among developers, owners and professionals of the environmental impact of their projects, (ii) recognize building owners and developers who adopt practices that are environmentally conscious and socially responsible, and (iii) identify best practices in the development, design, construction, management and operation of buildings.

Green Mark is applicable to both new and existing buildings. New buildings are assessed under: (i) Energy Efficiency, (ii) Water Efficiency, (iii) Site and Project Development and Management, (iv) Indoor Environmental Quality and Environmental Protection, and (v) Innovation. On existing buildings, "Site and Project Development and Management" is replaced with "Building Management and Operations". To ensure that buildings given the Green Mark are well maintained, they are assessed once every two years. There are four levels of Green Mark ratings: Platinum Star, Platinum, Gold and Silver. The BCA intends to use the results of the Green Mark scheme to develop a design guide for sustainable buildings.

The next section of the paper considers housing in Singapore. After discussing the administrative framework, it reviews the roles of public-sector and private-sector clients.

HOUSING IN SINGAPORE

Administrative Framework: Ministry of National Development

The Ministry of National Development (MND) are responsible for the planning and development of the built environment in Singapore, and thus for all aspects of housing. The statutory agencies under it include the Housing and Development Board (HDB), the national public housing agency, and the Urban Redevelopment Authority, the national physical planning and development control agency (which has the mission: "To make Singapore a great city to live, work and play in" (URA, 2005)).

The vision of the MND is: "A home for our people, a global city of distinction"; and its mission is: "To create the best physical and living environment for building a vibrant city, a robust economy and cohesive communities." The business objectives of the MND which are relevant in the context of this paper are:

1. To enhance our sense of belonging to Singapore through: provision of quality and affordable homes, community binding, development of green spaces and recreational infrastructure, and creation and retention of identity markers.
2. To meet present and future economic and social needs through: creative planning and management of scarce land resources, and promotion of the construction, real estate and agrotechnology industries.
3. To be an active partner in the remaking of Singapore.

Setting out the challenges facing his ministry, the Minister for National Development, Mr. Mah Bow Tan (Mah, 2005), declared that the MND:

> ...will guide Singapore's continued development as a city of distinction, characterized by its architectural and urban design excellence and a high quality living environment. We will continue to ensure affordable quality public housing to meet the diverse needs of our people.

The ministry would promote architectural and urban design excellence, contributing to the development of a distinctive city, with a quality built environment which would enable Singapore to distinguish itself from other cities. It would review and strengthen the statutory framework to ensure that buildings are of good quality, safe and elder-friendly. The minister reiterated the government's commitment to further improve the housing situation.

Public-Sector Client: The Housing and Development Board

The vision of the HDB is: "Affordable homes, vibrant towns, and cohesive communities." Its mission is: "We provide affordable quality homes, we create and rejuvenate our towns, and we promote the building of communities." The HDB was established in 1960 to address the poor housing conditions of a large number of people in Singapore at that time. These included unhygienic and possibly hazardous slums, and crowded squatter settlements. By 2004 to 2005, the HDB had completed 976,962 residential units and some 83% of Singaporeans lived in public housing flats compared with only 9% in 1960 when the HDB was set up (HDB, 2005). It had also built 16,553 shops and eating houses, 223 markets and food centres, 18 swimming complexes, 12 sports complexes, 25 bus interchanges, and 44 community centres. Table 1 shows key statistics on the HDB's activities in 2004 to 2005.

Table 1. Key Statistics of HDB's Activities, 2004–2005

Key Indicator	
Estimated percentage of resident population living in HDB flats	83
Estimated resident population	2,939,000
Percentage of resident population living in home ownership flats	81
Residential projects completed	6,164
Residential units awarded	4,851
Residential projects under construction	13,729
Units under management in HDB towns	879,566
Projected ultimate units under management in HDB towns	1,403.000

Source: HDB(2005)

The HDB plans and develops comprehensive towns. It undertakes or commissions research and development to ensure that it is able to provide homes with cost-effectiveness and high quality standards. Through renewal and upgrading programmes, it introduces new features, facilities, and improvements to its older estates and towns to ensure their continued relevance to the needs of the residents.

The HDB considers its strategy to have comprised three fundamentals. Firstly, as the sole agency in charge of public housing, it was able to adopt effective resource planning and allocation, making it possible to secure land, materials and personnel for large-scale construction to achieve economies of scale, and optimize physical and other results. Secondly, the HDB adopted "a total approach" which enabled it to deal with housing "as a seamless whole", from planning and design to land assembly and construction, and thereafter, allocation of completed units, and management and maintenance of the townships. Finally, the government provided strong

support in the form of political and financial commitment, as well as relevant legislation.

The HDB declares that it is committed to minimizing the impact of its activities on the environment. It set up the Green Environment Committee in 1997. In 1999, it formed a Task Force to steer the board towards more environmentally-friendly practices. The HDB was the first statutory board in Singapore to obtain ISO 14001:1996 certification for all its functions (in May 2002). The HDB has a clearly articulated environmental policy. It is currently collaborating with the National University of Singapore to develop an environmental assessment system for residential buildings.

HDB projects have won several awards in Singapore and overseas for aspects including their environmental features. For example, its projects recently won the top three awards in the public-sector category of the FIABCI Prix d'Excellence Awards 2006. The winner was the S$51 million upgraded precinct named Marine Terrace Breeze, completed in 2004. Its distinct design features include a stylized "fins & sail" on the top floors. At the ground level, there are private lobbies, sheltered corridors and garden enclaves with lush landscaping. Goodview Gardens was the second-placed project. Its focus is to provide a green sanctuary. It consists of 13 north-south orientated 25 and 28 storeys high residential blocks providing 2,128 apartments. The landscaping combines tropical planting with abundant use of natural materials like timber and stone. The multi-storey car park is positioned at the edge of the precinct and adjacent to the mass rapid transit railway line, to act as a noise buffer. The third place winner of the public-sector category was Blocks 203A to 205A in Punggol West, consisting of 13 residential blocks, 16 storeys high, with a total of 1,208 flats. The residential blocks embrace a central precinct green. Within each precinct, the residential blocks lie along the perimeter enclosing a 4-storey car park with a roof garden.

Private Developers

The private client organizations have also embraced the environmental agenda and are instituting measures to ensure that their housing units have the necessary environmental features.

City Development Ltd. (CDL)

One of Singapore's largest developers, City Development Ltd. (CDL), is exemplary with respect to its attention to sustainable development. The company is "committed to offering a living environment that is conducive for a healthy and comfortable lifestyle". The company considers supporting the conservation of nature and the environment as being complementary to its business

commitment. It has formulated an Environment, Health and Safety (EHS) Policy to monitor and control the impact of the organization's activities on the environment. CDL was the first private property developer in Singapore to be awarded both ISO 14000 and OHSAS 18000 certification for property development and project management services in 2003. The company believes that its EHS certification bears testimony to its commitment to drive EHS issues from a client perspective, and to deliver quality homes that are easy to maintain and efficient to operate.

CDL introduces innovative ecological features into the homes it builds to promote greener living. In addition, its homebuyers are encouraged to "recycle, reduce and reuse"; this is supported by the firm's Care and Recycle Programmes at some residential developments such as Guilin View, Sunshine Plaza and Trellis Towers. In planning a new development, CDL makes efforts to preserve the natural foliage and to integrate the natural terrain into its landscaping. Table 2 shows some of the environmental features in three of its selected condominium projects including Savannah Condo Park, the company's first "eco-condo".

CDL was one of only two companies to be awarded the Singapore Green Plan 2012 Award in 2005. This award is presented to individuals and organizations which are considered to make outstanding contributions towards the attainment of environmental sustainability in Singapore. The firm also won the prestigious Singapore Environmental Achievement Award (SEAA) 2004 of the Singapore Environment Council. CDL is one of very few companies in the world which meet FTSE4Good's Socially Responsible Investments standards of corporate social responsibility. It was recognized for working towards environmental sustainability, and developing positive relationships with stakeholders. CDL won the Merit Award for Best Public Relations Work for the Environment at the PR in the Service of Mankind (PRISM) Awards 2002 for its PR Eco-Campaign which included CDL's seminal Shop & Conserve Programme, Singapore Green Map, Nature Series Corporate Calendars and other eco-friendly initiatives. CDL won the national Green Leaf Award in 2000 for being the first developer in Singapore to install eco-friendly lifts and pneumatic refuse collection systems in selected condominiums, and for setting aside large proportions of site area for greenery and landscaped gardens in its projects.

CDL's projects feature prominently in the annual awards for good performance in many aspects, provided by the BCA. Table 3 presents the environmentally responsible features of CDL's projects which won four of the eight Green Mark awards presented in 2006. The influence of CDL on its business partners has also borne fruit.

Table 2. Environment-Friendly Features in Some CDL Residential Condominiums in Singapore

Features	Savannah Condo Park	Changi Rise Condominium	Goldenhill Villas
Water taps built in planter boxes for residents to maintain high-rise gardens	X		
Lush landscaping	X	X	
Energy saving lighting fitted along ventilation walls, boundary fences and other common areas		X	X
Rooftop air turbines that provide energy efficient cooling and reduces utility bills			X
Energy-saving air-conditioning systems for all houses	X		
Eco-friendly architectural design that creates convection wind to cool the residence naturally			X
Specially designed roof gardens that provide rooftop insulation to minimize dependency on air-conditioning			X
Solar panels installed in the clubhouse to convert solar energy into usable electricity to be used in selected rooms and water heaters for the clubhouse	X		
An odourless and mechanized pneumatic waste disposal system that removes solid waste from refuse chutes in individual homes to a sealed compactor within the bin centre or a mobile truck	X	X	
A designated green corner with colour coded bins placed at strategic locations to encourage residents to recycle	X	X	
Use of environment-friendly building materials such as recycled wood chips in laminated flooring instead of timber to help conserve natural resources and the environment	X	X	
An ecological pond that maintains water clarity and controls odour, algae and bacteria growth by recirculating the water through an aerobically active filter bed	X	X	
Provision of bicycle racks to encourage residents to cycle as an alternative to driving	X		

Source: www.cdl.com.sg/cdl2.nsf/ws.htm

Consultancy and construction firms which undertake its projects have some of the best practices in Singapore's industry. Tiong Seng Contractors (Pte.) Ltd. won the coveted Construction 21 Best Practice Award in 2006 (it was the only winner that year) for implementing a wastewater recycling system for silt water management and recycling for use in construction. The system had been procured and adapted with the encouragement of CDL, and used on several of its residential condominium projects undertaken by the contractor.

Table 3. Environmentally Responsible Features of CDL Projects Which Won Green Mark Gold in 2006

Residential Project	**Environmentally Responsible Features**
City Square Residences	• Construction using diaphragm wall uses less strutting materials • Extensive use of solar-powered light-emitting tiles, pole lights, bollard lights in landscaping • Dual chute pneumatic refuse collection system segregates recyclable and non-recyclable waste • Extensive use of sunpipes to send light into the three basement levels • Use of silt treatment and water recycling plant to recycle treated water for washing and cleaning
St Regis Hotel & Residences	• Self-cleaning ceramic façade cladding system saves water • Condensate water recycling saves up to 19,300 m^3 of water per year • "Wetstep" silt water treatment system saves 3,210 m^3 of water per month • Motion detection system is integrated with lighting for private lift lobbies • Dual chute pneumatic refuse collection system segregates recyclable and non-recyclable waste
King's Plot 3 Residences	• During construction, water treatment system was used to recycle treated water for washing and cleaning • All units are supplied with 4 ticks energy labelled air conditioning systems • All units are provided with dimmer controls in living/dining and master bedrooms • Tanks on fourth storey collect rainwater to be used for watering plants on ground floor by gravity fall
The Sail @ Marina Bay	• Construction using peanut-shaped diaphragm wall eliminated strutting, making the working environment safer and cleaner • Staircase shelter – uses less concrete and steel for construction and less materials for accessories • Solar powered system for heating pool and powering aircraft warning lights • Dual chute pneumatic refuse collection system segregates recyclable and non-recyclable waste

Source: BCA (2006)

Other private developers

As noted above, other private developers in Singapore also ensure that their residential projects are planned, designed and constructed in an environmentally responsible manner. Table 4 shows the environmental features of the projects of other developers (other than CDL) which won the Green Mark award in 2006.

In the next section, some recommendations for possible action to improve the housing situation and the sustainability of house completed in each country are presented.

Table 4. Environmentally Responsible Features of Residential Projects of Developers Other Than CDL Which Won Green Mark Gold in 2006

Residential Project (Developer)	Environmentally Responsible Features
RiverGate (Riverwalk Promenade Pte. Ltd.)	• Sprawling landscape on the ground; green vista is extended vertically to top of towers • Water drip line system, operating with timers and rain sensors, are installed in the sky and roof gardens • All systems have dual flushing system water closets • All units are provided with inverter multi-split air-conditioning systems • Guard houses use recycled water collected from integrated basins to flush toilets
The Tresor (Keppel Land Realty Pte. Ltd.)	• Waterless urinal in clubhouse toilet • Ductless mechanical ventilation fans in basement car park • Use of recycled plastic in equipment at children's playground
The Azure (FCL View Pte. Ltd.)	• Solar powered light-emitting tiles, pole lamps, bollard lights in landscaped areas; solar powered water heater in clubhouse changing room showers • Use of sunpipes to send light into basement carpark • Environmentally-friendly lightweight plastic grid for turfing along fire engine access way • Pneumatic refuse collection system segregates recyclable and non-recyclable waste
Varsity Park Condominium (CapitaLand Residential Singapore)	• Blocks of buildings are oriented to reduce direct sunlight into apartment units • Basement carpark has about 20% opening for natural light and ventilation, eliminating the need for full mechanical ventilation and water sprinkler fire-fighting system • Gearless traction elevator

Source: BCA (2006)

RECOMMENDATIONS

The National Framework for Action

The need to provide adequate standards of housing for each of the citizens of every country is a pressing issue. There is the need for a national housing policy which articulates this need, declares the intention to meet it, outlines strategic and tactical initiatives, sets specific targets to be achieved based on accurate and credible assessments of the present condition and future requirements, and provides for an administrative mechanism for implementing the strategies. The government should provide incentives for sustainable housing. These could be offered through the development control process, for example, by enabling developers to make proposals incorporating features of sustainability to have higher levels of intensity of development.

The national housing standards should include clear features corresponding to the criteria for sustainability. In each country, the necessary features should be determined through research. The results of building assessment schemes such as the Green Mark in Singapore can be used to refine and improve the stated standards in the policies. Environmental criteria should also be covered in the national building statutes and codes, to provide them with legal backing.

Annual competitions on environmentally responsible design of housing should be organized by the institution of architects and the umbrella body of clients. To provide an incentive to designers, the annual competitions should be real "live" events; specific developers should provide real sites for the exercise, and be willing to commission the designers of the top three entries each year, and to invest in the projects. Annual awards for sustainable housing could also be offered to clients, and the design and construction teams of particular projects. If such awards give the projects a desirable mark, enhance the value of the housing units, and thus, bring prestige to the owners, they will be well sought after.

Clients, professional consultants and builders could be educated on the broad issues of sustainable development and the environmental and other matters which they give rise to in the arena of housing. This educational programme should be jointly organized by the national agencies for housing and for environmental protection, the professional institutions, the contractors' association, and the umbrella grouping of clients.

Projects on which the sustainability criteria are successfully brought together, and which offer many examples of good practice, both locally and overseas, should be documented by the construction industry development agency, and the case studies disseminated

as widely as possible among administrators and practitioners.

Clients' Role

Developers of residential units should show their commitment to the protection of the environment by articulating it in their corporate policies, visions, missions, and objectives, and including coverage of sustainability in their annual reports. The developers should then require the professionals who plan and design their projects, and the contractors which build them to incorporate the relevant features. In procuring the services of professionals and contractors for their housing projects, developers should scrutinize and take into consideration their environmental performance record.

The public client should provide an example for the private-sector clients and the construction industry by adopting good practices in the planning, design, construction and management of residential units. These examples should be widely disseminated in the industry. Smaller developers' companies could pool their resources, to enable them to exercise control of the features of the main items they procure, and to gain economies of scale.

End Purchasers and Users' Role

If end purchasers and users are educated, and become committed to the need to protect the environment, they can constitute a market force which will compel the public and private developers to respond appropriately by ensuring that the designs of their units are environmentally sensitive. Thus, an awareness creation and education programme on the key features of sustainable housing for the general citizenry could be instituted. End purchasers and users in each country can form an association(s) to represent their interests to clients and the design team. The nucleus for this could be a grouping of existing management committees of condominium-type housing estates.

CONCLUSION

The building and operation of housing units has a negative impact on the quality of the world's environment. The effort of developing countries, especially those with high populations such as China and India, to improve the quality of life of their populations will put even greater stress on the earth's environment. In many countries, there is the need to enhance the number and quality of housing units in the stock. It is also important to increase accessibility and affordability to the ordinary citizen. Actions in all of these

regards have been, and are being, taken in most countries. A range of possible initiatives can further improve the situation. These are required: (i) at the national level, taken by governments and associations of industry practitioners, (ii) in the form of actions by the clients, and (iii) among end purchasers and users.

ENDNOTES

1. A version of this article was presented as a Keynote Paper by the author at the National Housing Symposium in Penang, Malaysia, 3–4 August 2006.

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