China Building Green Practice

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"Green China will be much more challenging than Red China." – Thomas L. Friedman, New York Times, November 2nd, 2005.

Abstract

The first "International Green Building Conference" (by government ministries of MOHURD, MOST, NDRC, MEP) took place in 2005. In 2006, China released "Evaluation Standard of Green Building"**,** a national green building standard, and in 2008 a building labeling system, the "Chinese Green Building Evaluation Label". Based on several influential green demonstration building practices, The Natural Resources Defense Council (NRDC) helped China to develop the national standard and local green building guidelines through the Agenda21 project**,** the first LEED gold certified building in China; Beijing Olympic Village, the LEED project processing first LEED gold certified neighborhood in China; Beijing Energy and Environment Center, the first existing energy retrofit demonstration for a government program; and the PLA Green Demonstration Project, the first green military facility practice. Apart from high levels of performance of each of the projects, they have had remarkable influence on China's building strategy and policy. However, there are still barriers for green building in China's building market. This paper serves as a window showing the accomplishments, and the challenges of moving the largest building body in the world onto the green route.

Building Energy Efficiency and Green Building Development in China

The following facts are important representative of China's building industry and building market profile:

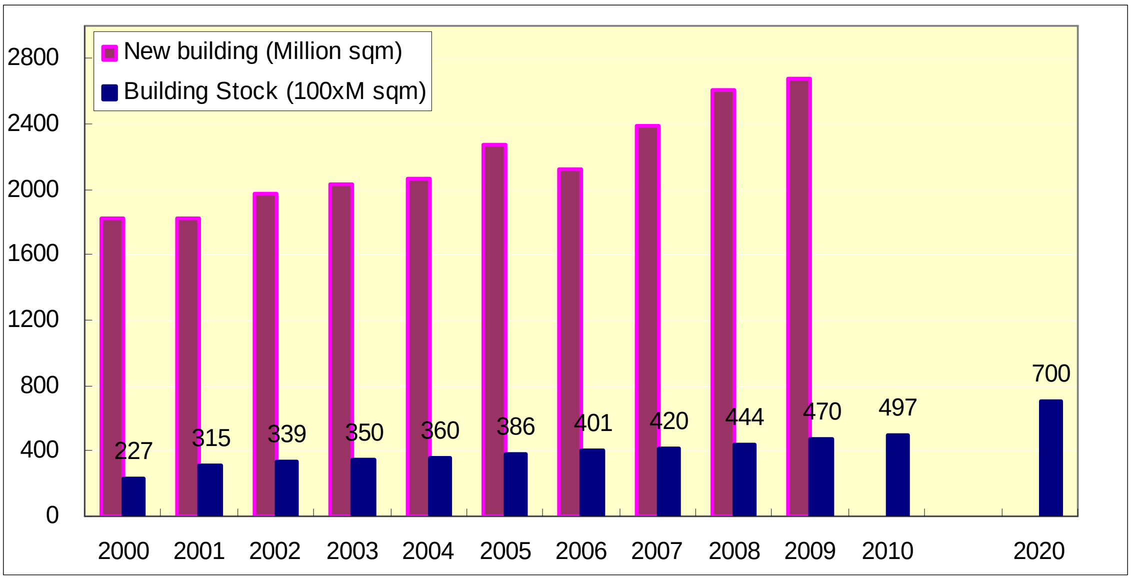
1. Since 2000, nearly half of all new buildings in the world were built up in China. According to China development plan, Chinese building stock will rise to 70 billions square meter in 2020, nearly three times that of 2000.[1]
2. 95 percent of existing buildings are not energy efficient to comply with the current Chinese building energy saving design standards.[1]
3. Green building movement in China is growing rapidly. In 2000, there is no LEED registered projects. In 2004, there were 4 projects LEED registered, and in 2009, there were more than 200 LEED registered projects. China is becoming one of the most active green building markets.
4. China's building energy use has significant impact on the climate change because of huge energy consumption.

At the beginning of the 21st century, Chinese building professionals thought green building as more greenery than others, few knew building energy efficiency strategy. Although the China Ministry of Construction launched the "Building Energy Conservation Regulation" in 2002, the building industry still produced energy inefficient buildings.

Since 2003, China began to recognize the environmental pressures and f fast economic growth under coal-fired energy production were not sustainable. The national policy guidance shifted towards the notion of "sustainable development"[2]. Economic development priorities shifted focus to include the quality of the environment, rather than simply the development quantity. Building energy efficiency and green buildings were often mentioned in official speeches. China's President Hu Jintao, gave his understanding of sustainable buildings, as "four efficiencies and one protection"[3] (meaning efficiency of land, energy, water and materials, all in protection of the environment), that clearly shaped the definition of green building.

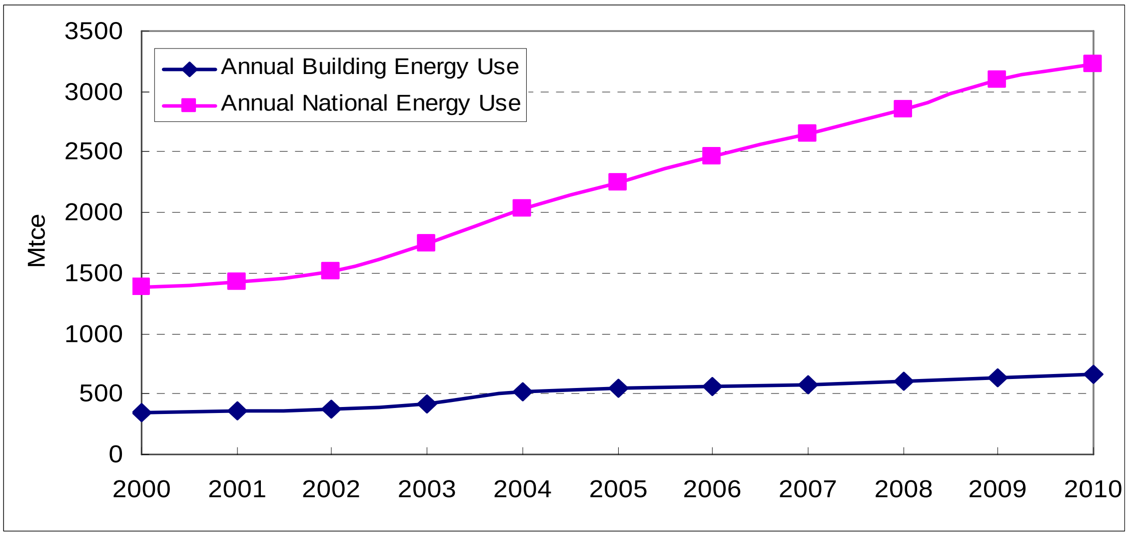
Economic data shows that each year new buildings contributed over 1.8 billions square meters since 2000, over 2 billions square meters since 2003, and up to 2.5 billions square meters after 2008. Such growth will continue to be recorded at least to 2020.[1]

Fig 1. China new building and existing building stock growth [4]



Source: China Statistic Yearbook 2000-2009

Fig 2. China Building Energy Use (Million tons Coal equivalent) [7 8]



Source: Annual Development Report on China Building Energy Efficiency, 2006-2009

China building stock consumes roughly 21~26 percent of total national energy use, which does not include the energy use in construction processes or in building materials production and transfer. It is estimated that 46 percent more of energy use can be attributed to buildings if all aspects of building production are included [5].

In China, coal contributes with 68.7 percent to national energy mix.[6] The national energy curve illustrated in figure 2 reflects the stifling growth of pollutant emissions and GHG emissions. China established an ambitious goal to mitigate coal dependence pressure, by the introduction of 15 percent non-fossil energy in Chinese energy minx by 2020 (stated by executive meeting of China State Council in 25 November 2009).

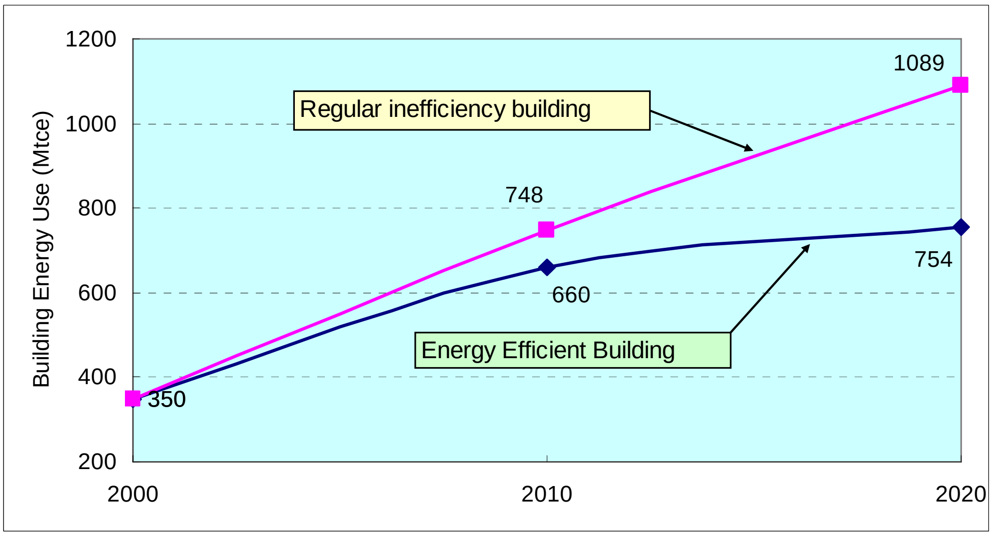
Building Energy Saving Design Standards Development and Target:

Various national building energy codes and green building ventures had been implemented since 2003, and more and more new buildings have been designed and built energy efficient. China's pathway of building energy efficiency was as follows:

- Since 2000, all new residential buildings were required to be 30 percent more efficient than buildings in 1980's.
- Since 2006, all new residential buildings were required to be 30 percent more efficient than previous phase, this was the 50 percent energy efficiency goal comparing to building of 1980's. A number of cities, such as Beijing, Shanghai and Shenzhen, increased their residential energy efficiency goals from 50 percent to 65 percent by 2007.
- From 2011, all new residential buildings will be 30 percent efficient more than previous goal. This is the 65 percent energy efficiency goal comparing to building of 1980's.
- Commercial/Public building energy design standards since 2005 required a 50 percent energy efficiency goal compared with commercial building energy use in the 1980's.

In implementing the basic goals of their government building energy plan (2007-2020), China can reduce its building energy use by 335 million tons of standard coal equivalent by 2020.

Fig 3 China Building Energy efficiency goal [9]



Since 1996, when China started to think about building energy efficiency, NRDC and international agencies, such LBNL, WWF, began working on energy efficiency in collaboration with the Chinese governments, institutions, and organizations advocating energy efficiency and clean energy use. Based on NRDC experience of building energy promotion in other places, NRDC got involved in codes and policies development, pilot project practices, trainings, shared experience and lessons with Chinese.

China developed the “Energy Saving Design Standard for Heating Zone Residential Buildings” in 1995, which was the first to document the building energy efficiency requirement for northern China residential buildings. It set a 30 percent energy efficiency goal and was increased up to 50 percent efficiency goal after 2000. At that time, it functioned as a voluntary standard and very few projects complied with.

The Chinese Ministry of Construction had Chongqing, the biggest southwest city, develop local energy saving design standard for residential buildings in 1999 that were based on standard experience and lessons learned. It was the first time building energy efficiency in China’s transition climate zone was considered. The government hoped that it would become the template for a future national design standard of residential building energy efficiency for each climate zone. The local standard was launched in 2001, and the national standard was developed in 2003. It was the first energy standard to set performance requirements and require energy simulation as a measurement tool. In order to help with implementation of the standard, Lawrence Berkeley National Laboratory provided an energy simulation tool DOE-2, an energy simulation tool, to China under DOE program, which later became widely adopted. The standard also set the building energy efficiency at a 50 percent reduction comparing to building of 1980’s.

Subsequently, in the year leading up to 2006, a number of national building energy efficiency standards were released and implemented, including a residential building energy efficiency design standard for cooling zone in 2005, a building energy efficiency design standard for commercial building in 2005, and a building lighting energy efficiency standard in 2004.

The “National Code of Building Energy Construction Acceptance GB50411-2007” was launched in 2007. Building energy performance was adopted into official final building inspection procedures. Moreover, all standards and codes relevant to building energy efficiency were adopted as mandatory requirement for building design and construction in China. In 2005 and 2007, the Chinese “Construction Law” and “Energy Conservation Law” were revised to include building energy efficiency sections.

In 2008, the Chinese government released two legal regulations of the “Civil Building Energy Savings” and “Public Organizations Energy Savings” to enhance the legal framework for building energy efficiency. The building industry was required to save energy in amount of 101 millions of standard coal equivalent through retrofitting over 150 millions square meter of existing buildings and enforcing new building compliance with building energy codes (about 70 million via new buildings energy efficiency codes enforcement and 20 million via existing building energy retrofitting), in order to achieve national energy intensity reduction goals of the “China National Climate Plan” during China’s 11th Five Year Plan (2006-2010).

As building energy efficiency is the basic element of green building, China’s Ministry of Science and Technology signed an agreement with US Department of Energy in 1998 to build an energy efficiency demonstration project in Beijing, in order to guide China’s building industry energy design and construction through the model practice. It is named the Agenda21 project, which later became widely known as China’s first green building.

Agenda21 was so successful in green performance and market benefits that China's central government and building administration demanded government buildings to be retrofitted according to the template. Furthermore, China's own green building standard was requested to be developed based on the project's performance and practice. The standard was finally launched in 2006, two years after completion of Agenda21 project. The standard rates residential buildings and commercial buildings differently. Like the LEED rating system, the standard rates green buildings based on performances of energy efficiency, water, land use and indoor environment quality. The big difference compared to LEED is that it includes "building green operation" as an rating component. The Ministry of Construction held its first "International Green Building Conference" in 2005 which regularly takes place in the first quarter of every year. Furthermore, a "Green building innovation award" was established by the government to recognize outstanding green building projects every two years.

In 2007, a green building labeling system was officially launched. It rates up to three stars depending on a project's green performances. Normally one star and two stars rating can be qualified by both central and local building administration while a three stars rating need be qualified only by central government administration. The rating process is based on the China green building standard and "Green building labeling regulation" and "Green building labeling rating technical guidelines for design and operation".

For building energy codes enforcement, China's Ministry of Housing and Urban & Rural Development launched a national building energy labeling system in 2008, based on Shanghai's building energy labeling system. The Shanghai building energy labeling system adopted The US HERS index which indicated building energy code compliance at 100, and zero net energy use at "0". NRDC worked with Shanghai to establish the building energy performance indicator under collaboration with US RESNET, a home energy rating system which has been adopted by US home mortgage industry and EPA's Energy Star.

NRDC Green Building Project Cases in China

Several pioneer pilot projects and green initiatives have served to promote green buildings in China. The term "green building" became commonly known in last decade, but without an clearly understanding of green building. Therefore, early abuse of "green" for commercial profit fogged real green projects, and brought disrepute to green building before 2000. NRDC, USGBC and US Department of Energy worked hard with China's Ministry of Science and Technology in green building advocacy through education and pilot project practice, and finally China was able to shift its green building industry to a truly green route. Here are the few demonstration projects that played a key role in igniting China's green building flame.

1. Agenda21

The project began in 1999, as an the agreement between China's Ministry of Science and Technology and the US Department of Energy, with a goal of building a demonstration project that would introduce effective building energy and green technologies to China's buildings construction industry.

The building locates in downtown Beijing. It has 130,000 square meters in floor space. The project was coordinated by NRDC and LBNL to demonstrate how a green building could dramatically reduce carbon emissions and environmental impacts. Through two years of design and planning of green strategies by experts from both the US and China, technologies were optimized and integrated by of efficiency and cost balance. Construction of the building began at the end of 2002 and completed in February of 2004. Both US and Chinese governments gave it an official grand completion celebration for its high green performance. In 2005, it earned LEED Gold rating, and was the first LEED certified project in China. It was also the top winner of first China "Green Building Innovation Award" in 2005. The significance of the green demonstration was to show the Chinese building industry that a green building can be built at common market cost with currently available building technologies when the right strategies are implemented.

Based on its energy performance monitoring date, the building has achieved carbon dioxide emission reductions of 1,690 tons per year, and over the lifetime of the building, these savings are equivalent to a total of 170,600 tons of CO_2 emission reductions reduction**.** Its green performance can be highlighted by following points:

Energy Efficiency Performance

Over years of operation, the building energy monitoring data shows that Agenda21 has achieved over 60 percent energy saving compared to ASHRAE 90.1-2002 standards and 74 percent energy saving compared to typical office buildings in China. Annual power use to run the building is on average about 52 kwh/m2, while typical office buildings in Beijing are about 180~220 kwh/m2.

Energy savings are achieved by improving the building envelope, windows, natural ventilation and daylighting systems, High efficiency T-5 lighting fixtures with digital control system achieve lighting power density of 5 w/m2. The China Building Energy Efficiency Lighting Design Standard requires it to be 9 w/m2 as a future performance goal.

A heat recycle system salvages 76 percent energy from the building's exhaust and an Ice Storage System offers summer cooling cost savings by making ice in off-peak hours and cooling the building in peak hours. In addition, a solar PV system and solar water heating system provide 5.2 percent of the building's power demand and satisfy the entire building's hot water needs.

Water Conservation

One gallon per flush pressure toilets, waterless urinals (the firstly adopted in China), water efficient faucets and showers, and storm water reuse technology dramatically improved the building's water efficiency performance. Two years of data have demonstrated savings of more than 40 percent in potable water use and over 60 percent reduction in wastewater generation. Because the building uses local plant species for the roof garden and landscaping accompanied by a storm water collection and reuse system, it needs no potable water for irrigation and saves about 10,000 tons of potable water per year.

Efficient & Sustainable Land Use

The building is on a redevelopment site, adjacent to various mass transportation options, including the subway system and several bus lines within walking distance. Dozens of free bicycle storage spaces are provided. 65 percent of the roof area is covered roof garden with more than 80 species of native plants. The vegetated roof is a comfortable retreat for occupants and greatly reduces the heat island effect. Integrative utilization of roof garden, pervious paving, native landscaping, and storm water recycling not only significantly reduces runoff by 90 percent, and also mitigates the urban heat island effect, improving the local micro-climate.

Sustainable Building Materials Use

More than 90 percent building materials and products used in this project were harvested or manufactured locally, greatly reducing the environmental impact of transportation. Bricks and cement for construction had 5% recycled content such as fly ash from power plants. All carpeting within the building was made of recycled, low emission materials. During the site preparation process, all deconstruction materials were completely collected and conveyed to rural areas for reuse, which significantly diverted landfill waste.

High Quality Indoor Environment

Indoor environment quality is maintained to comply with standards of ASHRAE 62.1 of indoor air and ASHRAE 55 of indoor thermal comfort using CO2 monitoring, variable flow control, green building materials and elements utilization. Environmental health encourages occupants to alter smoking habits; staff smokers dropped to 8 percent from 25 percent in six months.

2. Beijing Olympic Village

The Beijing Olympic Village was used to house 16,000 plus athletes and officials of the 2008 Beijing Games. The project was financed and built by a local developer. Residential units were sold after the Games as high-end condos. The developer's goals were to build a project that met the strong environmental commitment of the Chinese government on the Games, while increasing the project's market appeal at a cost that assured a reasonable profit margin.

It is located at the Northeast of the Olympic Park, adjacent to the Olympic Forest Park, 10 minutes walk to National stadium (Bird Nest). It uses 27.55 hectares land that was redeveloped from old residential district. After the Games, 42 mid-rise residential buildings provide a total of 1800 new homes. Total construction area is 413,250 m2, including 380,000 m2 for permanent residential buildings and 33,250 m2 for various public buildings temporarily constructed for the Games. Below ground: 142,410 m2 of garage space for 2,800 vehicles was constructed. The project began construction in 2006 and was completed before the Game in June 2008.

As it was an important green component for a green Olympics, the green strategies of energy efficiency, renewable energy adoption, water saving, environmental materials use and best indoor and outdoor comfort were priorities during project design and planning. The green highlights of the project are:

Energy Efficiency and Renewable Energy Applications

All the buildings were designed with high energy envelope and low-e windows and all residential units were sunlight oriented in order to improve the indoor environment. A wastewater heat pump is the heating and cooling source for the project to replace the regular

heating coal boiler and air conditioners, which can reduce coal burning 24,000 tones and 61,000 tons CO2 emission. Furthermore, it is cleaner and quieter. Roof installed hot water systems can produce 600 tons hot water each day to meet hot water demand of athletes during the Game and residents after. The system can bring energy savings of 5,570,000 kwh each year to reduce CO2 emission near 5,600 tons. All lighting fixtures in the project are efficient CFLs. There are 760 solar energy lighting fixtures, outdoor LED lightings and sunlight duct for underground lighting saving energy equivalent of 15,000 kwh each year. The efficient lighting system can save a total of 580,000 kwh every year.

Water efficiency

Grey water from buildings and storm water are treated on site and collected for reuse in toilet flushing and landscape irrigation. All pavements in the project are designed water permeable in order to reduce runoff. More than 76,000 tons of potable water is saved by water recycle strategies, and it achieved an 80 percent runoff reduction over regular neighborhoods in a similar scale.

Materials

Most pavements and outdoor components are made of recycled material, such as wasted plastic and wasted slag. All recycling containers are recycles made of wasted plastic and wood. Over 90% of the building materials were locally sourced close to Beijing, which greatly reduced transportation energy and help shorten the construction schedule.

Micro-energy demonstration project

As a highlight green point, US Department of Energy and Beijing administration planned the reception center (used as a kindergarten after the Game) to be a micro energy demonstration through energy integrative design and 23 green technologies, including solar passive design, high performance building shell, solar heating and cooling storage system, solar water heating, solar and wind power on site supply. The contribution of renewable energy sources is more than 60 percent, based on its own reduction of buildings energy consumption. Winter cool storage can provide 20 percent of the cooling requirement.

The project was LEED certified under the Neighborhood Development rating system in 2008 and was the first China LEED green neighborhood project.

3. Beijing Energy and Environment Center Demonstration Project

China with its huge number of building stock , provides a challenge to energy retrofit the existing buildings with the right mix of policy and technology. Beijing has over 160 millions square meter of existing commercial buildings and most are energy inefficient. The project was planned by the government as a demonstration project of an existing building energy retrofitting program, to find a practical way and to setup a guide through the experiences from the program. Beijing plans to energy retrofit 40 million square meters of existing building till 2011. The building was built 25 years ago in a simple energy system, the innovation was to retrofit its energy system and improve the indoor environment at low cost to setup a template of governmental and public building energy retrofits program.

The building has a 3,665 square meters of floor area, located in the downtown district and housed by a government energy agency. Because it is governmental property, the project cost was stringently restricted to $600 per square meter. Final project budget review showed the project cost 3 percent less than the threshold.

Retrofitting Strategies Applied

Based on the project energy audit and condition, retrofitting strategies were designed to greatly improve the building envelope, upgrade the lighting system, replace the heating and cooling systems, introduce renewable energy systems, and keep existing structure components as much as possible to avoid construction waste.

An insulation technology combined with exterior finishing coating was used to give existing wall a new “float” insulation coating, to improve thermal performance 80 percent. All windows were replaced by double Low-E glazes with thermal break aluminum window frame, to reduce heat transfer factor from 4 w/(k.m2) to 1.4 w/(k.m2). Glare control devices were also integrated into windows. Structure shading was designed to prevent solar gain of south and west façades.

A new air conditioning system replaced old inefficient air conditioners to have higher efficiency. Fresh air ventilation was installed with heat recycle device to reduce energy leakage during heating and cooling seasons by 76 percent.

Water fixtures were replaced by efficient fixtures with flush control devices, such as waterless urinals and low water toilets to save 15 percent water than before. Storm water management introduced highly permeable pavement and an entire on site storm water collection system. An underground storm water cistern can meet whole landscape irrigation demand and leaves no storm water runoff from the project.

All the lightings were replaced by high efficient fixtures controlled by intelligent system, power data showed 3,200 kwh was saved each year. Besides efficient lighting fixtures, the building installed 4 sunlight duct systems to introduce day-lighting to the core area. The building total lighting load designed 18 kw, but the roof photovoltaic system capacity is 25 kw that can totally provide lighting energy requirement. A heat conduct solar hot water system can meet the domestic hot water demand. Original electric water heating equipments and boilers were removed during the project.

The Beijing Energy and Environment Center is a governmental energy management sector. It has a large data center to monitoring real time energy use data for more than 500 local government buildings and local big energy users. Through green data center technology, the “EnergySmart” servers achieve 30% more power saving, which contributes 20% the building operation energy saving.

The project retrofitting practice set a guideline to Beijing existing retrofitting program. Strategies in the project were required to be replicated in other retrofitting projects covered by government grants. The project has registered for LEED certification. Its green performance is being documented.

4. PLA green demonstration project

Green practices of military facilities are quite different to civil construction. In responds to the national energy conservation plan, China's military force decided to take green steps in construction of military facilities. The basic idea was to develop green military facilities construction guidelines through the pilot project practice.

The project locates in the campus of PLA Engineering University in Chongqing. It aims to acquire both LEED certification and a Chinese green building label. It will be used as an officer training center with about 12,000 square meters in floor area, it is a 6-storey building including offices, conference rooms and classrooms.

Sustainable Design for the Project

Energy calculation of design plan showed that the project energy savings will be at 75 percent, the level of commercial building energy saving design standards. In order to achieve green performance, strategies of energy efficiency, water saving and environment friendly materials were designed in the planning and construction plan. A ground heat pump system serves as the energy source of heating, cooling and hot water production. Because local climate is wet and there are few sunny days, heat drive natural ventilation and mechanical ventilation were integrated into the design to keep indoor comfort. A high efficient building envelop with a high thermal mass factor is designed to resist summer heat. The lighting of the project is very efficient which integrates daylight orientation design and LED lighting fixtures with auto control. A roof garden and structure shading was designed to reduce heat island effect in the summer. In order to protect the surrounding natural environment, the construction plan includes a storm water design for collection and reuse, runoff reduction and native plant species protection.

The project will start construction soon and is to be completed within a year. It is a registered LEED project and project documentation will be taken along as project progresses. NRDC is collaborating on the project to support greening the PLA.

China Green Building Barriers and Opportunities

Green building policies are the byproduct of building energy efficiency policies in China. Green building is undoubtedly an important approach for the building industry in terms of environmental responsibilities and market benefits, but green building practice is not still as popular as building energy efficiency practices yet. There are some barriers in China to green building promotion.

Barriers

There are barriers in economic policies and people's cognition of green building concept. Green building is voluntary option while building energy efficiency is mandatory in China. Although there are policies for green building incentives in China, the number of green buildings is still small in new buildings. More green building incentives are required to accelerate the market transformation. The Chinese government is developing policies for enhancing green building market initiatives through finance and tax system reformation.

In China's building industry, there is a misunderstanding to green buildings that they may cost more. Cost increase is always a result of faulty knowledge of green strategies and mistakes in project construction. Green buildings can be built at any building market cost if the right strategies are employed from the early stages of the building process. The project-costs of NRDC cases are nearly same as common market project because these projects implemented smart strategies and adopted green approaches at the initial stages. Additional project costs are always generated by modifications, the right design and project plan can help avoid a lot of extra costs. Individual green technology may cost more, but there are two ways the addition can be offset: 1) technologies integration to balance overall project costs by mitigating certain cost additions of a technology or products through others savings; 2) green benefit of energy savings and productivity increase are much more than initial investment. In general, green investment can always be paid back by lifetime sustainable benefit.

Opportunities

In 2008, the Vice Minister of China's Ministry of Housing and Urban & Rural Development Mr. Qiu Baoxing estimated that the green building business in China is worth $3 billion each year. Lately, China has set a GHG emission reduction target to reduce carbon intensity 40~45% by 2020 in response to climate change. China will sets more stringent energy conservation and environment goals in next five years plan (Twelfth Five Year Plan, 2011-2015). That is expected to driving more and more new buildings and existing buildings go to green.

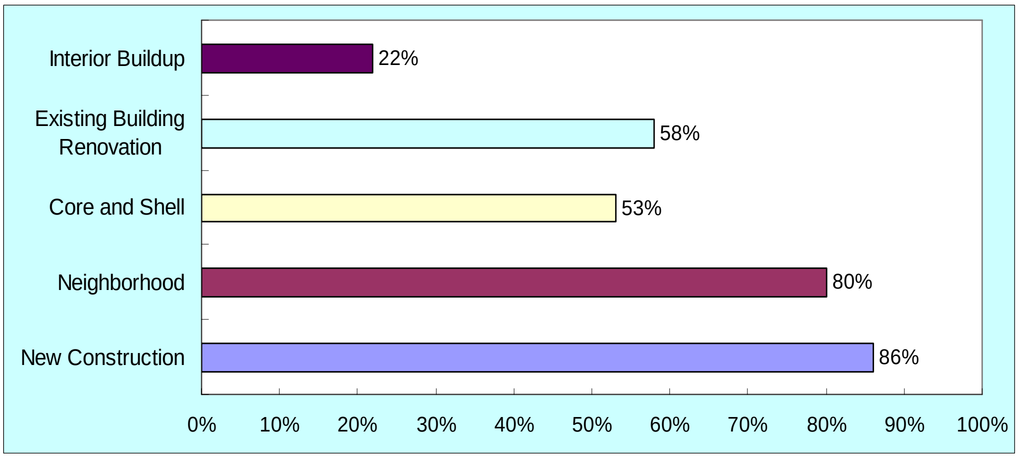
In order to stimulate the green building and energy efficiency market, the government launched several demonstration programs to provide financial grants to green and energy pilot projects. Local governments also supported grants to such pilot projects. For instance in Shanghai, if a project qualifies as a green demonstration in government program, around $65 per square meter can be subsidized. More incentives are being planned for successive year to accelerate the green building market with government grant supports.

With demand of building more energy and water efficiency, more low carbon technologies are required. But technologies and high quality products are still far less than market demand, like low cost efficient windows and insulation materials. In some cases, better green design cannot find suitable technology or material.

Not only do individual buildings need to go green but neighborhoods and cities are also under consideration to take part in green innovations in China. If 5 percent of new buildings are built green in China, the number can equal 100s millions square meters each year. The China's Green Building Council did a market survey in 2009 to show that in next five years, new buildings and residential neighborhoods would be the fastest growing areas in green building.

Besides green building promotion, green neighborhood and city less carbon plans are also being developed and implemented. NRDC helped Shenzhen in 2008 to develop a local "Design and Planning Guideline of Green Neighborhood", with the aim of more efficiency in land, energy, water and materials, more affinity to mass transportation and less vehicle dependence to create healthy and inhabitable environment also reduce their environmental impact.

Fig 4 New building and neighborhood will be the fastest growing green building market[10]



Source: White paper of 2009 China green building International Conference

Green operation and maintenance are also important not only to keep building green performance. but also create new market opportunity as well. Green and clean technology and products is becoming rapidly growing market in China. China Center of Disease Control and Prevention estimated in 2008 that there is a $44 billion market opportunity in Chinese building HVAC cleaning market in more 5 millions in using large central HVAC stations.

Furthermore, the green technology education is becoming an essential course to professional training. More and more training courses of green building are being taken in governmental programs and market promotion.

China has started green engine and its building green journey. If China buildings become green, we would have a sustainable environment. If we missed it, we would miss the world.

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