Proposal for Construction of Low Energy Buildings in China

MSc. Hu Runqing

June 2007

WORKING DOCUMENT PREPARED IN COMPLIANCE WITH THE AGREEMENT SIGNED BY AND BETWEEN CNERCHS AND THE RENEWABLE ENERGY AND ENERGY EFFICIENCY PARTNERSHIP (REEEP)

FUNDED BY: THE RENEWABLE ENERGY AND ENERGY EFFICIENCY PARTNERSHIP

Content

1. Development Status of Energy Efficient Buildings in China

Since the global-wide oil crises in 1973, the importance and pressure of energy saving have been recognized by the developed countries. Energy efficiency in buildings in these countries has become a critical component in overall energy saving efforts. Measures of techniques, policies, regulations have been taken to promote the energy efficient building strategy implementation. Compared with the developed countries, building energy saving efforts in China have not started until 1980 and progressed slowly. The development of strategies for energy efficient buildings in China can be divided into four periods:

Period One: Initiation (1980-1987)

Since 1980s, due to the gap between energy demand and supply, energy shortage became a bottleneck for China national economy and social development. In order to alleviate the energy shortage and to improve economic profit, a set of national policies on energy saving buildings have been issued:

On Jan 12, 1986, the State Council issued the "Notice on issuance of trial management regulations on energy saving activities in China" (Document No. State Council (1986) No.4). In the section of residential daily energy consumption management, it is clearly indicated that while ensuring appropriate living environment inside a building, the building design should carefully consider its shape and orientation, improve outer protection frame, select energy saving materials and facilities, and fully use natural light to reduce energy consumption for lighting, heating, and cooling systems. Central heating systems should be designed and implemented for both the new residential houses and non-residential buildings.

Under the support of State Economic and Trade Commission and the National Development and Reform Commission, China Ministry of Construction conducted a study project on China civil building energy efficiency investigation and energy efficient building technologies and standards, from which the first energy efficient building technical standard-"Energy Efficiency Design Standards for Civil Buildings (for Residential Buildings with Central Heating Systems)"was enacted on August 1, 1986 (JCJ26-86). Following this standardization, some provinces and autonomous regions made their own detailed technical code for implementation according to the local climate conditions, building construction technologies, materials, and building products.

On September 25, 1987, the former China Ministry of Construction and Environment Protection, National Planning Commission, State Economy Administration, and the National Building Material Administration jointly issued the "Circular on implementation of the "Energy Efficiency Design Standards for Civil Buildings (for Central Heating Residential Buildings)"(Document No. city design (87) No. 514), indicating that since energy efficiency in buildings can result in significant economic and social benefit, local government should pilot the standards at small scale and promote the experience gained from the pilot projects in design, engineering, and management and improve public awareness of the energy efficiency buildings.

Period Two: Pilot and Demonstration (1988-1994)

In 1988, the Ministry of Construction, the National Bureau of Construction Materials, the Ministry of Agriculture, and the National Administration of Land Use jointly organized a leading group for renovation of building wall materials and energy efficient building activities and set up a dedicated office. The leading group issued the Comments on Speeding up Building Wall Material Renovation and Energy Efficient Building Promotion. The bill was approved by the State Council and started implementing nationwide. Pilot projects of residential energy efficient buildings were conducted in Harbin, Heilongjiang in Northeast China and in Chengdu, Sichuan in Southwest China areas.

The Lighting Design Standard for Civil Buildings (GBJ133-90), an energy efficient building related national standard, was issued by the Ministry of Construction in 1990. In April 1991, the No.82 Premier Order was issued by the State Council, indicating that the residential building followed "Energy Efficiency Design Standards for Civil Buildings (for Central Heating Residential Buildings)"(Document No. city design (87) No. 514) is defined as energy saving building in northern area and its fixed asset investment tax will be exempted.

In 1992, the National Development and Reform Commission, the State Economy and Trade Commission, and the Ministry of Construction jointly issued the Regulation on requirement of energy saving section in the feasibility study report for basic construction and technical improvement projects. This regulation required that energy efficiency must be evaluated for a construction project in its proposal, evaluation, and approval stages. Meanwhile, the Ministry of Construction carried out energy saving building pilot and demonstration projects in China's eight provinces. These projects provided expected results in driving the building energy saving activities and promoting experiences from the pilots.

The Ministry of Construction enacted the Technical Codes for Heating Engineering Technologies in Civil Constructions (GB50176-93) in 1993 and issued the first energy efficient design standards for commercial buildings in the same year, i.e. The Energy Saving Design Standards of Heating and Air Conditioning Engineering for Tourism Hotels, which marked the start of commercial building energy efficiency activities. In September 1994, in order to meet the requirement of industrial steaming and residential heating, the Management Regulations for Urban Boiler Heat Supply was enacted by the Ministry of Construction. This regulation was to promote urban central heat supply system to save energy and mitigate environment pollution.

Period Three: Moving Forward (1995-2000)

In March 1995, the Ministry of Construction and the National Development and Reform Commission together issued the Circular on Improving Urban Heat Supply System Planning Management. The management procedures required that centralized urban heating systems should be promoted, planned by scientific principle, and implemented in an integrated and systematic way in order to avoid randomness and duplication in the construction.

In May 1995, the “Ninth Five-Year Plan and Long-Term Plan by 2010 for Energy Saving Buildings” was made by the Ministry of Construction. This planning document defined objectives, targets, tasks, and implementation phases of the energy efficient building activities in the country. It identified three phases for residential building energy efficiency: I. new buildings with central heating systems shall achieve 30% energy consumption reduction before 1996, based on the energy efficiency level designed in 1980-1981; II. Starting from 1996, further 30% of energy consumption will be targeted; and III. Based on the phase II target, further 30% energy efficiency will be improved. The technical improvement of existing buildings with poor heating conditions and large energy consumption will start from the year 2000 in some selected key cities and conducted at all cities. The program will be finished by 2010. According to this objective, the total energy saving by 2000 can be expected as much as 27 million tce.

The “Energy Efficiency Design Standards for Civil Buildings (for Central Heating Residential Buildings)”was revised in 1995, became an industrial standard code (JCJ26-95), and started implementation since July 1, 1996. The standard requires that the heating energy saving target 50% reduction based on 1980-1981 general standard (building energy efficiency contributes 30% and heating system contributes 20%), but investment on heat preservation and door and window obturation will not exceed 10% of the total construction cost, and the total investment reclaim duration will be no more than 10 years. It was estimated that the standard practiced in the northern part of China would result the total energy saving as much as 10 million tce between 1996 and 2000.

In 1997, China's eighth National People's Congress Standing Committee passed the Energy Saving Law (ESL), which defined the energy saving as a long-term strategy for the national economic development. This was the first time that reasonable energy utilization, energy consumption structure adjustment, energy saving activities, renewable energy development, and the technical improvement for energy efficiency are secured through legislation. The ESL will no doubt contribute to the country's energy saving, improve energy efficiency, environment protection, and the economic and social sustainable development. The ESL will help standardization and promotion of the energy efficient building activities.

Based on the ESL, the National Development and Reform Commission, the State Economy and Trade Commission, and the Ministry of Construction made a revision on the energy saving evaluation requirement issued in 1992 and therefore enacted in December 1996 the "Requirement and Evaluation of Energy Saving Section in the Feasibility Study Report for Fixed Asset Construction Projects" and defined standard process of the evaluation. In the documentation, it is specified that energy saving section must be included in a construction project feasibility study report and be evaluated by a qualified consulting agency; otherwise the proposal will not be accepted by administration.

In 1999, the Ministry of Construction issued the "Comments on Promoting Modern Residential Housing Industry and Improving Building Quality". In this government announcement, 50% energy saving of the new buildings are defined as a major target for improving residential building quality. To further drive the energy efficient building activities, the Ministry of Construction issued the Civil Building Energy Saving Management Regulations in February 2000 in a form of minister order (Minister of Construction Order No. 76) to encourage development of energy saving walls, doors and windows, central heating systems, co-generation, and solar and earth thermal technologies as well as other energy efficient building technologies such as energy efficient lighting and air conditioning. The regulations also encourage heat-meter based user charging systems, product certification system, and specified management procedures for energy efficient building proposals, design, engineering, quality assurance, and operation management. For those construction projects do not follow the energy saving design standards and have not achieve the energy efficiency target, economic punishment can be executed or even the project stopped, or qualification lowered.

Period Four: Popularization (2001 to present)

Based upon the previous preparations in technologies, standards, organization structures, and policies for energy saving building activities, the pilots and demonstrations at selected cities are popularized gradually to the entire country.

In February 2001, the Ministry of Construction approved and issued the Proof-Check Standards for Residential Buildings with Heating Systems (JGJ132-2001). In July 2001, the Energy Efficient Design Standards for Residential Building in the Hot in Summer and Cold in Winder Regions (JCJ143-2001) according to the climate conditions at transition areas. The issuances of these standards marked the common practice of China's energy saving building activities and the energy efficient building entered a nation-wide popularization stage.

In the Planning Guidelines for Energy Saving Buildings during the Tenth Five-Year Plan Period made by the Ministry of Construction, it is clearly specified that "reducing building energy consumption is one of the important part in China's sustainable development strategy. Practice of energy efficient buildings will benefit peoples living and working environment, secure a sustainable economic and social development, mitigate air pollution, reduce the green house gas emission, and slow the global warming process. Therefore it is an important part of both building construction and energy efficiency.

The implementation of the Energy Efficient Design Standard for Residential Building in the Hot in Summer and Cold in Winder Regions that has become effect since October 1, 2002 presume that a residential building project should consider energy efficiency during its design stage. The designed building will not only be elegant, but also energy efficient. The standard specifies mandated requirement for building outer winder areas, roof window areas and heat-conducting factors, home-controllable air conditioning systems, and evaluation of possible water pollution from air conditioners.

The Ministry of Construction issued the announcement for issuance of the Ministry of Construction promoted and limited technologies on March 18, 2004, to encourage application of outer wall warm-keeping technologies, building doors and windows components, energy efficient heating systems, and solar heater systems.

On April 20, 2004, the Ministry of Construction circulated the management regulations on energy efficient building pilot and demonstration projects (communities), which regulated strictly the energy efficient building project proposal, supervision, and evaluation procedures, in order to play the best role of the pilot building projects and help popularization in the whole country.

The Ministry of Construction's "Technical Guidelines for Construction Projects issued on April 23, 2004 requires that the construction industry must strictly follow the energy efficient building design standard and by 2010, all the large and medium cities and counties shall follow the Civil Building Energy Efficiency Design Standard (for Residential Buildings with Heating Facilities), the Energy Efficient Residential Building Design Standard in the Hot in Summer and Cold in Winder Areas. The required building design techniques will help ensure energy saving, improve inside -building heat environment, and reduce CO_2 emission.

The already issued national level energy efficient building policies and management regulations, standards, and technical codes are as follows in Table 1 and Table 2.

Table 1. Policies and Management Regulations Related to Energy Efficient Buildings:

	Policies and Regulations
1	Announcement on Implementing the Energy Efficient Design Standards for Residential Buildings in the Hot in Summer and Cold in Winter Areas (Ministry of Construction, Science and Technology Bureau[2001]239).
2	The Planning Guidelines for Energy Efficient Buildings during the Tenth Five-Year Plan Period (Ministry of Construction, Science and Technology Bureau[2002]175).
3	Announcement on Implementing the Energy Efficient Design Standards for Residential Buildings in the Hot in Summer and Cold in Winter Areas (Ministry of Construction, Science and Technology Bureau[2003]237).
4	Announcement on strengthening evaluation of energy efficiency for civil building projects (Ministry of Construction, Science and Technology Bureau[2004]174).
5	Circulars on strictly executing energy efficient design standards for new residential building projects (Ministry of Construction, Science and Technology Bureau [2005]55).
6	The management regulations for national green building innovation awards (Ministry of Construction, Science and Technology Bureau [2004]183
7	The State Council announcement for strengthening city planning program (State Council [1996]18)
8	Circular of the State Council on strengthening the supervision and management

	for city and township planning activities (State Council [2001]13)
9	Announcement on implementing the State Council's circular for strengthening the supervision and management for city and township development planning activities (Construction Planning[2002]204)
10	The State Council Announcement on re-evaluating and regulating land use management for construction project at development zones (State Council [2003]70)
11	Announcement on further strengthening and regulating the planning and management of development zones (Ministry of Construction, Planning [2003]178)
12	Announcement on implementing the State Council decisions for deepening reform and strict management of land use management (Ministry of Construction, Planning [2004]185)
13	Announcement about strengthening the city planning revision and evaluation work (Ministry of Construction, Planning[2005]2)
14	Notice on implementing the energy saving activities issued by the State Council Management Office (Ministry of Construction, Science and Technology Bureau[2004]87)
15	Management Methods for Certificating Commercial Residential Building Specification (Trial version) (Ministry of Construction, Housing[1999]114)
16	Management procedures for national housing demonstration projects (Ministry of Construction, Housing[1999]274)
17	Announcement on eliminating the poor quality products in housing projects (Ministry of Construction, housing [1999]295)
18	The bulletin on the promoting and restricting some applied construction techniques (Ministry of Construction, Bulletin No. 218)
19	Announcement on issuance of comments on promoting housing industry and improving housing quality (State Council, Management Office[1999]72)
20	Guidelines for Implementing Commercial Housing Decoration before Delivery (Ministry of Construction, Housing[2002]190)
21	Guidelines of Practical Techniques for Residential Buildings
22	Guidelines of Quality Techniques for Residential Building Projects
23	Technical Codes for National Housing Program Demonstration Projects
24	Study on techniques and economic policies for housing industry modernization
25	Guidelines for Residential Area Landscape Design
26	The Trial Management Regulations for the Selected Products in the Demonstration Projects of the National Housing Program.
27	Practical Guidelines for Concrete Plate Buildings.
28	Technical Requirement of Applying Residential Area Intelligent Systems.

Source: Bureau of Science and Technology, the Ministry of Construction.

Table 2 Standards and Norms for Energy Efficient Buildings.

No.	Standards and Norms
L	Heating engineering design norms for civil buildings, B50176—93
2	Energy Efficient Design Standards for Civil Buildings (for residential buildings with heating systems) JGJ 26—95
3	General Technical conditions for time-delayed lamp switch, JG/T 7—1999
4	Water-free Hydrazine Toilet GB/T 18092—2000
5	Technical codes for energy efficiency technical improvement of the existing residential buildings with heating systems JCJ 129—2000
6	Energy Saving Evaluation Standards for Residential buildings with Heating Systems. JGJ l32—2001
7	Design Standards for Energy Efficient Residential Buildings in the Hot in Summer and Cold in Winter Regions JCJ l34—2001
8	Procedures for evaluating construction project quality of water supply, drainage, and heating systems. GB 50242—2002
9	Procedures for evaluating construction project quality of ventilation and air conditioning systems. GB 50243—2002
10	Classification and Test Procedures for Heat Preservation Features of Building Outer Windows GB/T 8484—2002
11	Water Quality Standards for City Residence Water Supply Systems GB/T50331—2002
12	Project Quality Standards of City Sewage Water Processing Plants GB 50334—2002
13	Engineering Design Standards for Sewage Water Reuse projects. GB 50335—2002
14	Design Standards for Reusable Water Systems in Buildings GB 50336—2002
15	City Water Supply Network Leak Control and Evaluation Standards CJJ 92—2002
16	Classification of Urban Sewage Water Reuse, GB/T 18919—2002
17	Water Quality Standards for City Sewage Water Reuse GB/T 18920—2002
18	City Sewage Water Quality Requirement for Landscape and Environment Purposes GB/T 18921—2002
19	Standards for Residential Water-saving Equipment and Appliances CJ 164—2002
20	Design Norms for Heating, Ventilation, and Air Conditioning Systems GB 50019—2003

21	Energy Efficient Design Standards of Residential Buildings in the Hot in Summer and Cold in Winder Regions JCJ 75—2003
22	Standards of Heat Preservation Systems for Outer Walls using Inflated Polystyrene Plates plasterer materials JG l49—2003
23	Design Standards for Building Water Supply and Drainage Systems GB 50015—2003
24	Specifications and Technical Requirement for Intelligent Residential Communities CJ/T 174—2003
25	Design Standards for Building Lighting Systems GB 50034—2004
26	Technical Specifications for Outer Wall Heat Preservation Engineering JCJ l44—2004
27	Standards for Outer Wall Heat Preservation Plates JG/T 159—2004
28	Standards for Outer Wall Heat Preservation Systems using Glue Powder Polystyrene Granules JG l58—2004
29	Standards for Non-Touch Water Appliances CJ/T 194—2004
30	Design Standards for Energy Efficient Public Buildings GB 50189—2005
31	Evaluation Standards for Green Buildings, March 2006, GB/T 50378-2006
32	Certification of Eco-Residence Community and Eco-Environmental Housing Projects

Source: Bureau of Science and Technology, the Ministry of Construction.

2. Technical and Design Standards for Energy Efficiency Buildings in China

2.1 Main standard for building energy efficiency in China

Ministry of Construction has been begun to compile design standard for building to control and reduce the building energy consumption at the beginning of 1980’s. Based on the principle of residential building prior to public building and North prior to South, Ministry of Construction has enacted a series of design standard for residential building energy conservation. These standards are shown as followed:

- *Specification for Civil Building Thermal Design* (JC24-86) was enacted in 1986(ministerial standard)

- *Design Standard for Civil Building Energy Efficiency(Heating and Residential Building*) JCJ26一86was enacted (ministerial standard) ,

- *Design Criterion for Heating, Ventilation and Air Conditioning* GBJ19－87 was enacted in 1987(national standard)

- *Criterion for Thermal Design of Civil Buildings*（GB50176－93）was enacted in 1993(national standard).

- In 1995, *Design Standard for Civil Building Energy Efficiency(Heating and Residential Building*) (JCJ26—95) was enacted to take the place of JCJ26－86.

- In 2001 and 2003, *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Region(JGJ134—2001，J116 －2001)* and *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Region*(JGJ75—2003，J275—2003) were enacted, which aim at hot summer and cold winter, and hot summer and warm winter region respectively.

- *Design Standard for Public Building Energy Efficiency* was enacted in 2005(GB50189—2005). At present, three design standards for residential buildings in different climate region will be combined to become one national standard for residential buildings efficiency.

The design standard for energy efficiency focused on the residential building and public building. For residential building, the design standard is to increase energy efficiency ratio of heating, ventilation and air conditioning equipment or system through improving heat preservation and heat insulation for building envelope. For public building, the design standard aimed at increasing energy efficiency ratio of heating, ventilation and air conditioning equipment or system through improving heat preservation and heat insulation for building envelope. At the same time, some measures for improving lighting equipment efficiency were adopted. Under the condition of ensuring the comfort factor for indoor thermal environment, these measures will reduce the total energy consumption from heating, ventilation and air conditioning (and lighting) to reach the target prescribed in standard

1) *Design Standard for Civil Building Energy Efficiency (Heating and Residential Building*) (JGJ26—95)

The standard was enacted in 7th December 1995 and implemented in 1st June 1996, which is an industry standard. The standard was applied on the design for building thermal performance and heating energy efficiency of new and expanding building in severe cold and cold region.

In China, the severe cold and cold region include Northeast, North of China and Northwest. There is 90 days with the average temperature below or up to 5℃ for years in succession. The period with low temperature in Manzhouli is longest in these regions. The area of Manzhouli accounts for 70% area of China.

The basic object is shown as follows. Under the base of general design standard for residential building from 1980 to 1981, the heating energy consumption will reduce 50% (including 30% building efficiency and 20% heating system efficiency) through adopting effective technology measure during building and heating design. However, the investment for improving the heat preservation of building and gas tightness of door and window should not exceed 10% of construction project, and the pay-back period will be below 10 years. The investment for saving one ton coal equality should not exceed the investment for mining one ton coal equality during implementing energy efficiency measures in heating system. The standard described the index of hot loss of building and coal consumption of heating and building thermal design and heating design. The standard emphasized the heat preservation performance of building envelope and efficiency of heating system.

The index of heat loss of building and coal consumption are two important indexes for evaluating building energy consumption. The standard detailedly regulated the limited value of the index residential building heat loss index in different region and the limited value of heat transfer coefficient in different building envelope.

2) *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Region*(JGJ134—2001，J116－2001)

The standard was enacted in 5th June 2001 and implemented in 1st October 2001. The standard was applied in the design for building energy efficiency of new, renew and expanding building in hot summer and cold winter region.

The hot summer and cold winter region includes the middle-lower reaches of Yangtze River and its surrounding region. The range of this region is at the south of LongHai road, and at the north of South Mountain, and at the east of Sichuan Basin, which includes Shanghai, Chongqing, Hubei, Hunan, Jiangxi, Anhui and Zhejiang. Furthermore, the region also includes the east of Sichuan and Guizhou, the south of Jiangsu and Henan, and the north of Fujian, and the south of Shanxi and Gansu, and the north of Guangdong and Guangxi. The region involves 16 provinces, cities and municipalities and is an area with mass population and developed economy. The hot summer and cold winter zone is a region without heating, so the design for building did not consider heating and say nothing of reducing temperature of the air condition in the summer. The building envelope has bad thermodynamic performance and the thermal environment quality is bad in the city and the efficiency of heating and air condition is low.

The standard has double meaning. Firstly, the standard should ensure the thermal environment quality in the city to improve residential standard. Secondly, the standard also improves the energy efficiency of heating and air condition for implementing the strategy of sustainable development and realizing the target of saving 50% energy in China.

The main content of this standard includes: the design index for indoor thermal environment and building energy efficiency, the design index for building and building energy efficiency and thermal performance, and energy efficiency design for heating, ventilation and air condition. These designs emphasize the measures for heat preservation and heat insulation of building envelope and building ventilation and shading. At the same time, the standard also regulates the select for the method and equipment of building heating and air condition in the residential building.

The standard regulates that the energy consumption of heating and air condition should be controlled within the range regulated under ensuring thermal environment in the city. Based on this standard, in winter, the temperature of bedroom and living room should be 16-18℃, and the frequency of air exchange should be one times per hour. In summer, the temperature of bedroom and living room should be 26-28℃, and the frequency of air exchange should be one times per hour.

The standard is a building industry standard. However, many building energy efficiency indexes, including the design index for building, the design index for building thermal performance and the integrated index for energy efficiency, should be compulsively implemented. The compulsive items related of building energy efficiency include:

- NO.3.0.3: The energy efficiency measure can adopt improving heat preservation and heat insulation of building envelope and energy consumption ratio of heating and air condition. Under ensuring the same index for indoor thermal environment, the energy of heating and air condition will save 50% comparing to the energy consumption without the measures.

- No.4.0.4: The area of outer-window (including transparency part of the door in terrace) should not be large. The heat transfer coefficient for outer-window with different direction and area ratio of window to wall should accord with the regulation in Table4.0.4

- No.4.0.7: The gas-tight grade of outer-window in 1-6 floor of building and terrace door should be within III grade regulated from *Graduation and Test Methods of Air Permeability for Building Outer Window* GB107(national standard). The gas-tight grade of outer-window in 7 floors and beyond 7 floors should be within II grade of this standard.

- No.4.0.8: The heat transfer coefficient and Index of thermal inertia of each part in building envelope should accord with the regulation in Table4.0.8. The heat transfer coefficient of outer-wall should adopt average heat transfer coefficient considering cold bridges of structure. The calculation method should accord with the regulation in Annex A of this standard.

- No.5.0.5: the sum of annual heating electricity consumption and air condition electricity consumption per building should be within the limited value in Table5.0.5, which is the sum of annual heating electricity consumption based on heating degree days and air condition based on cooling degree day.

- No.6.0.2: When residential building utilizes the central heating and air condition, the metering equipment for household temperature control and heat (cold) metering should be designed. The other design for energy efficiency of heating system should accord with the existing industry of *Design Standard for Civil Building Energy Efficiency (Heating and Residential Building*) (JGJ26). The design of central air condition should accord with the existing national standard of *Design Standard for Building Thermal Performance and Air Condition Energy Efficiency in Tour Hotel* (GB50189).

3) *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Region*(JGJ75—2003，J275—2003)

The standard was enacted in 11th June 2003 and implemented in 1st October 2003. The standard aims at the design for new, renew and expanding building energy efficiency in hot summer and warm winter region. According to the regulation of Ministry of Construction, the large and middle cities began to implement this standard in 2003 and small cities in 2005 and all towns in 2007.

The hot summer and warm winter region located the south of China, including Hainan, the most part of Guangdong and Guangxi, south of Fujian, little part of Yunan, Hongkong, Macao and Taiwan. There is longer summer and shorter cold winter in this region. The region has the high temperature during the whole year and high humidity. The annual range and diurnal range of temperature is low in this region. Furthermore, there is strong solar radiation and abundant rain fall in this region.

The building air condition in this region has rapidly developed. These cities with developed economy in this region, such as Guangzhou, had one air condition per household. Furthermore, there are many households with three air condition. In some region with the cold winter, such as Fuzhou, there were the more and more families utilizing electricity for heating. Because of the bad thermal performance of building envelope and low energy efficiency ration of air condition, there existed the serious electricity waste and bad indoor thermal comfort and environment pollution. Therefore, the work for building energy efficiency should be implemented under the situation.

The objective of this standard is to improve the energy efficiency of heating and air condition and realize the target of saving 50% energy under the premise of ensuring the indoor thermal environment quality and improving living standard of resident. The main content of this standard includes: the calculation index for building energy efficiency design, design index for building and thermal performance energy efficiency, the integrated evaluation for building energy efficiency design, the design for air condition and heating ventilation, the simplified calculation method for outer shading coefficient in summer and winter, the simplified calculation method for the code of annual heating electricity consumption of air condition. The standard emphasizes the area ratio of window to wall, thermal insulation performance of envelope, outer shading measures and natural ventilation.

The standard divides the hot summer and warm winter region into south and north region based on the average temperature in January. In south region, the design for building energy efficiency should mainly consider the air condition in the summer and give attention to the heating in winter. In north region, the design should consider air condition and can take no account of the heating in winter. The cities in south region include Fuzhou City, Putian City and Longyan City in Fujian Province, Meizhou City, Xingning City, Longchuan City, Xinfeng City, Yingde City and Huaiji Country in Guangdong, Hechi City, Liuzhou City and Hezhou City of Guangxi.

The design index for indoor air condition in the summer should adopt the followed value: 1) the indoor temperature of living space is 26℃, 2) the air exchange frequency is one times per hour. The design index for indoor heating of south region in winter should adopt the followed value: 1) the indoor temperature of living space is 16℃, 2) the air exchange frequency is one times per hour.

The standard is a construction industry standard. In the standard, the integrated evaluation related to building and building thermal energy efficiency design and building energy efficiency design, the main item about air condition and heating ventilation are compulsive item, so these items should be compulsively implemented. The compulsive items related to the energy consumption in the standard are as followed:

4) *Design Standard for Public Building Energy Efficiency* (GB50189—2005)

The standard began to be implemented in 1st June 2005. It can be applied in the design for building energy efficiency in new, renew and expanding public building. Under the condition with same indoor environment parameter, the total energy consumption of heating, ventilation, air condition and lighting should reduce 50% during the whole year. The main content includes: the calculation parameter of energy efficiency design for indoor environment, building and building thermal design, energy efficiency design for heating, ventilation, and air condition.

5) *Green Building Evaluation Standard*（GB/T50378—2006）

Ministry of Construction and General Administration of Quality Supervision, Inspection and Quarantine promulgated *Green Building Evaluation Standard* GB/T50378—2006 in 7th March 2006 and implemented in 1st July 2006 in the whole country.

In 2004, Ministry of Construction established "Green Building Innovation Prize" in China, and established and printed *Management Measures of Green Building Innovation Prize* and *Use Rule of Green Building Innovation Prize. Based on practice,* Ministry of Construction wrote and enacted *Green Building Evaluation Standard*. In 2006, Ministry of Construction established *Applied Rule of Green Building Innovation Prize Review* and organized to compiling *Review Standard of Green Building Innovation Prize*. The review standard regulated that the index system for green building innovation prize review will adopt *Evaluation Index System of Green Building Evaluation Standard*.

Green building means the building will save energy by the greatest degree (saving energy, land, water and material), and protect environment and reduce pollute to provide health and comfort and efficiency using space for people and harmoniously mix with nature during the building life cycle.

The green building evaluation aims at the building group or individual building. When evaluating the individual building, the index involved in the outdoor environment should accord with the evaluation result for surrounding environment of this building. For new, renew and expanding residential building should be evaluated after one year of the building used. The objective of green building evaluation may be residential building or public building.

The index system of green building evaluation includes saving land and outdoor environment, saving energy and energy utilization, saving water and water resource utilization, saving material and material resource utilization, indoor environment and operation management. Each index includes control item, general item and priority item.

In this standard, the control item, general item and priority item of residential building adds up to 76 items, among which 27 is control item, 40 is general item and 9 is priority item. For public building, the control item, general item and priority item adds up to 83 items, among which 26 is control item, 43 is general item and 14 is priority item.

The necessary condition of green building is residential building should accord with all request of control items in fourth chapter and the public building should meet with the request of control items in fifth chapter.

The green building should meet with all requests of control items and can be divided into three grades according to fulfilling numbers of general item and priority item. The grade will be confirmed based on Table.3 and Table 4.

Table 3 The number request for green building grade (residential building)

	Grade	★	★★	★★★
1	General item (40 items)			
A	Saving land and environment （8 items）	4	5	6
B	Saving energy and energy utilization （6 items）	2	3	4
C	Saving water and water utilization (6 item)	3	4	5
D	Saving material and material utilization （7 items	3	4	5
E	Indoor environment quality （6 item）	2	3	4
F	Operation management （7 item）	4	5	6
2	Priority item （9 item）		3	5

Table 4 The number request for green building grade (public building)

	Grade	★	★★	★★★
1	General item (40 items)			
A	Saving land and environment （8 items）	3	4	5
B	Saving energy and energy utilization （6 items）	4	6	8
C	Saving water and water utilization (6 item)	3	4	5
D	Saving material and material utilization （7 items	5	6	7
E	Indoor environment quality （6 item）	3	4	6
F	Operation management （7 item）	4	5	6
2	Priority item （9 item）		6	10

The evaluation index has quantitative items and qualitative items. The request for quantitative items can be confirmed by direct compare. The request for qualitative items should be confirmed after integrated analysis according to practice status. The evaluation conclusions for qualitative items are only two kinds, “pass” or “no pass”. The conclusions have not medium state between these two kinds. When one item involves many requests, the evaluation will be approved after each request is met.

Saving energy and energy utilization is an important content of green building. In building and building thermal energy efficiency design, the standard considered the programming design and building thermal design should accord with or exceed the standard of energy efficiency design. In heating, ventilation and air condition design, the standard regulates the energy efficiency of central heating and cold and heat source for air condition, the control and measure for central air condition and system temperature of air condition. The standard advocates and encouraged the renewable energy utilization, saving energy technology and measures, and CHP, and cogeneration of cold, heat and electricity.

The control items in saving energy and energy utilization include:

- Residential building thermal design and heating, ventilation and air condition design should accord with the approved or recorded national regulation for the residential building energy efficiency standard.

- When adopting central air condition system, the performance coefficient and energy efficiency for the selected cold water equipment or cell air condition should meet with the regulation from existing *Public Building Energy Efficiency Design Standard* GB50189.

- The building using central heating or central air condition should set up the facility for controlling indoor temperature and metering heat

The general item of saving energy and energy utilization include:

- Make use of the nature condition of the ground and rationally design building figure, direction, distance between building and area ratio of wall to window to obtain good sunlight, ventilation and day lighting, and design shading facility based on the demand.

- Select high-efficiency energy equipment and system

- When adopting central air condition system, the performance coefficient and energy efficiency ratio for the selected cold water equipment or cell air condition should exceed the grade from existing Public Building Energy Efficiency Design Standard GB50189.

- The public lighting should adopt light source with high efficiency and the other measures of saving energy. In the region with nature light should establish the time control or photoelectric control.

- In residential building with central heating or central air condition, the energy reclaiming system (equipment) should be established.

- Make good use of renewable energy, such as solar energy and geothermal energy. The using amount of renewable energy should account for 5% of the total energy consumption of building,

The priority items of saving energy and energy utilization include:

- The energy consumption of heating or air condition should be within 80% of regulated value from national standard or recorded standard of building energy efficiency.

- The using amount of renewable energy should account for 10% of the total energy consumption of building,

2.2 Problems of China Energy Efficient Buildings

2.2.1 The energy efficient building design standards are still behind international practice

Energy efficiency has been recognized as priority by the developed economy that standards for energy efficient buildings have been updated continually. For example, Denmark has revised its related standards for six times and the standards have been updated for four times. Along with the improved living standard and comfort requirement, the energy efficient building related standards in UK, France, and Germany have been raised 3-5 levels higher compared with the original ones (see Tab le 5 and Table 6.).

Table 5. Building Outer Structure Heat Transmission Factor Thresholds over the Years in UK

Unit:W/(m^2.K)

	Roof top	Outer Wall	Floor	Window
1965	1.42	1.70	—	—
1976	0.6	1.0	—	—
1982	0.35	0.6	—	—
1990	0.25	0.45	0.45	3.3
2002	0.15	0.35	0.25	2.0

Table 6. Building Outer Structure Heat Transmission Factor Threshold on the years in Germany

Unit: W/(m^2.K)

	Roof Top	Outer Wall	Floor	Window
1952	0.90	1.39	0.90	3.5
1977	0.45	—	0.90	3.5
1984	0.30	—	0.55	3.1
1995	0.22	0.50	0.35	1.8
2001	0.20	0.20～0.30	—	1.5

However the energy efficient building standards in China was formulated in 1986 and was modified only once in 1995. Technical specifications in the energy efficient building standards, such as outer structure heat transmission factors, central heating systems, ventilation, and air conditioning systems, are much lower than those in the developed countries. (See Table 7)

Table 7. Comparison of home and abroad building outer structure heat transmission factors: $W/(m^2.K)$

			Outer Wall	Outer Windows	Roof Top
China	Beijing	1986 Standards	1.28	6.40	0.91
		1996 Standards	0.82	4.00	0.60
	Harbin	1986 Standards	0.73	3.26	0.64
		1996 Standards	0.40	2.50	0.30
Sweden	Southern Areas		0.17	2.00	0.12
USA	Similar to Beijing Area		0.32(inside room) 0.45(outside)	2.04	0.19
Canada	Similar to Beijing Area		0.36	2.86	0.40
	Similar to Harbin Area		0.27	2.22	0.17
Japan	Hokkaido		0.42	2.33	0.23
Russia	Similar to Beijing Area		0.44	2.75	0.33
	Similar to Harbin Area		0.32	2.35	0.24
Denmark			0.20(each m^2weight<100kg) 0.30(each m^2weight>100kg)	2.90	0.15

2.2.2 Low execution rate of the energy efficient building standards

Because the current Chinese standards for energy efficient buildings are not mandated, they are not fully executed due to the weak enforcement. The issued standards are not followed in many provinces. According to supervision in 2000 to two municipalities in northern China and some provinces, it is found that only 6.4% in construction areas followed the standards. By the end of 2000, in the 7.66 billion square meters building construction areas (including 57.6% residential apartments) in cities and the 20.04 billion square meters (80% residential houses), only 180 million square meters or 0.6% of the total constructions areas, 2.3% in city construction areas reached the energy efficient building standards. By the end of 2002, there are only 230 million m2 completed energy saving buildings, accounting for 2.1% of the total city construction. In the new construction areas of 1 billion m2, only 6% can be considered as energy saving buildings. In the recent years, in the about 2 billion m2 new construction completed each year, only 50-60 million m2 are recognized as energy efficient buildings. This means that 97% of the constructed buildings are non-energy-efficient. Many of them did not follow the energy efficiency design standards.

The energy efficient building standards execution for new construction projects is not balanced in the whole country. This unbalance features:

(1) Regional difference: In general, northern areas develop faster due to the earlier issuance of the standards, while the transition areas and southern regions progress slowly at their starting stage. In the economically developed areas, the standards are executed better than the underdeveloped areas.

(2) Unbalance between cities and rural areas: Currently, the energy efficient building activities are mainly carried out in cities together with practical procedures and technical methods, while in rural areas, the activities are still not carried out. The new buildings are basically not following any energy saving standards, and without management procedures.

In terms of the existing 30 billion m2 construction in China, technical improvement of the buildings will involve many difficult issues such as financing, house ownership, and regulations, etc. Most of them are not energy efficient and are wasting a huge amount of energy everyday.

3. Case study of low energy consumption buildings

3.1 Progress of demonstration projects in China

In China, there are three kinds of demonstration projects related with low energy building, demonstration projects on energy efficiency building, demonstration projects on renewable energy buildings and demonstration projects on monitoring and control system for space heating.

- Demonstration projects on energy efficiency buildings were launched in 1999, 6 demonstration projects in 1999, 12 projects in 2001, and 2 projects in 2002. The demonstration technology mainly focused on the technology on external thermal insulation on wall and energy efficiency door and window.
- Demonstration projects on monitoring and control system for space heating was launched in 1990, mainly focus on the R&D of thermal monitoring and controlling system and testing it in the demonstration project.
- The demonstration projects on renewable energy buildings launched in 2006.

The demonstration technologies are the renewable energy technology related to the buildings, for example solar thermal system, solar PV system, heat pump and others.

In order to introduce the advanced technology, experience and models to China and promote the development of energy efficient buildings in China, Ministry of Construction cooperated with international agencies, foreign countries and society association and developed several international cooperation projects:

- Investigation of Building Energy Conservation in China was conducted during 1999-2000 sponsored by World Bank.
- Cooperated with Energy Foundation to conducted the development of Design standard for energy efficiency of residential buildings in hot summer and cold winter zone, the calculation of energy consumption of buildings, and the incentive policy research on energy efficiency buildings
- Sino-Canada Project during 1996-2003 focused on incentive policy research, standard and codes development, demonstration projects, training and disseminations.
- MOC/WB/GEF project Monitoring Innovation on Urban Centralized Space Heating in China: Tianjing city was selected as the demonstration city to demonstrate the technology of controlled home temperature and monitoring by habit and regulation reform on space heating charge system.

3.2 Demonstration projects in European

In European Commission, there are a lot of demonstration projects related to low energy and energy efficient buildings with a large number of subsidies. The following are three large demonstration projects in EU level. Besides these demonstration projects, some countries also have their own demonstration projects in national level.

- The CONCERTO: The CONCERTO is part of the 6th framework research program supervised by the DG Energy and Transport for the European Commission. The Program was launched in 2003, with a second call in 2005. Today, there are a total of 28 communities in 9 projects, each working to deliver the highest possible level of self-supply of energy, and about 20 other communities are about to start their project. Each CONCERTO community addresses its own specific solution. The initiative as a whole, focused on the integration of renewable energy sources (RES) and energy efficiency (EE)

Measures, involves eco-buildings integrating onsite RES with energy efficient building design and management, poly-generation, combined heat and power (CHP) and district heating (ideally using bio-mass). In addition, intelligent management of demand as well as local distribution grids and distribute generation are included.

- Bringing Retrofit Innovation to application in Public Buildings (BRITA-in PbBs) is one of four Eco-buildings demonstration projects in an energy demonstration initiative of the EU. The technology applications includes measures ate the buildings envelope like improved insulation and high efficient windows, advanced ventilation concepts like hybrid system integrated supply technologies like combined heat and power unites, energy –efficient lighting and integrated solar applications. The project will realized by the exemplary retrofit of 9 demonstration public buildings in the four participating European regions (North, Central, South, East).

- Sustainable Architecture Applied to Replicable Public Access Buildings (SARA) involves the demonstration of 7 highly sustainable and replicable Public-assess buildings in EC Member sates (Spain, Austria, United Kingdom, France, Italy and Slovenia) and one new Independent State (Uzbekistan). There are 15 participants in the project: the promoter and research organizations of the countries involved in the 7 demonstration countries plus research and technical development (RTD) for Germany. SARA aims to construct seven sustainable, cost effective, high energy performance, public-access eco-buildings that are immediately replicable at large scale in May location and demonstrated the cost–effective potential for improving the energy performance of Europe’s buildings. SARA stared in June 2004 and will finish in May 2008.

In 2006, in all countries of EU, energy performance labeling for residential and non-residential buildings (new and existing) was obliged. In all countries of the EU Directive on the Energy Performance of Buildings (EPEB) has to be translated to national legislation and tools for the implementation has to be developed. The IMPACT project, Improving energy Performance Assessment and Certification schemes by Tests, aimed to support National actors with the implementation of the directive and to contribute to the preparation of market actors for the introduction of energy labeling in 2006. For and effective implementation of energy labeling, aspects like quality control, tools and communication needed to be prepared thoroughly and tested. Within IMPACT energy performance certification for existing buildings is tested in practice in 6 countries: Belgium, Denmark, France, Germany, Spain and the Netherlands.

3.3 Case study in China

Under the framework of this project, 10 case studies of low energy consumption buildings are selected, including 5 public buildings projects and 5 civil buildings projects.

5 public buildings projects are:

- Tsinghua Super low energy consumption buildings, office building
- Demonstration buildings of Energy efficiency, Ministry of Science and Technology, office building
- Tianpu new energy demonstration building, office building and residence
- Meiyuan ecobuilding, Shandong Construction Engineering Institute, students dormitory
- Shanghai ecology demonstration building

5 civil buildings are:

- Beijing modern and myriad city, MOMA，top grade apartment
- Shanghai Wanke Longrunyuan, residence
- Shenzhen Taige Apartment, hotel-style apartment
- Lanzhou Hongyunyuan, residence
- Nanjing Jufuyuan, semi high-rise residence

The general information of these low energy consumption buildings, including complete time, location and climate region, construction area, cost, energy consumption, and technology evaluation, please see the table 8 and table 9, the detail information please find in the detail case study reports.

These 10 case studies locate in 7 cities, Beijing, Shanghai, Shenzhen, Nanjing, Lanzhou and Jinan, covering north China, east China and south China three climate regions.

3.4 Case studies in Europe

Under the frame work of this research, 10 European case studies of low energy consumption buildings are selected, including 3 office buildings and 7 residence buildings in the Netherlands, Spain, Germany, Portugal, Turkey, France, Australia, Sweden, covering north Europe, west Europe, temperate sea climate region, Mediterranean climate region and Alpine region.

The general information of these 10 case studies in European please see the table 10 and table 11, and the detail information please find in the detail case study reports.

Table 8 Technology of low energy consumption buildings case study in China

	Project	Major Energy Technology
1	Tsinghua Super-low Energy building	− more than 50 new technologies and new products were utilized to testing and disseminate − Adjusted intelligent buildings envelop, more than 10 technologies were used − Natural ventilation system and fresh air system − Fuel battery system − Heat pump − Natural gas cogeneration system − Solar PV − Solar thermal system − Dish solar power generation 3 kW
2	MOST Energy Efficiency Demonstration buildings	− A Sino-America energy efficient demonstration buildings − More than 60 new technologies were used − Solar PV system 15kW − Solar water heater − Balance ventilation heat recovery − Rain water recovery system − Solar PV and SWH supply for 5%-6% energy consumption
3	Tianpu New Energy Demonstration building	− Heat pump system for space heating and cooling − Solar water heater system − Solar PV system
4	Shandong Meiyuan Eco-building	− Passive house design − Solar water heater − Soalr PV system
5	Shanghai Eco-building	− Solar water heating system for space heating and cooling − Natural lighting and energy conservation light − Rain water collect system
6	Beijing Modern and myriad city·MOMA	− Ceiling radiation heating and cooling system − Rain water collect system − Heat recovery natural ventilation system
7	Shanghai Wanke Langrunyuan	− Good insulation − Low-E windows − Solar water heater − PV system for lighting − Natural ventilation system
8	Shenzhen Taige Apartment	− Natural ventilation system − Heat pump for hot water − High efficiency air conditioner and elevator
9	Nanjing Fujunyuan	− Solar water heater for domestic hot water
10	Lang Shi Residential block	− Ground source heat pump − Ceiling radiant cooling and heating system − Heat recovery ventilation system

Table 9 Insulated performance of the case study in China

	Project	Place and climate	Heat/cold load	U-value			
				wall	Roof	floor	Glazing
1	Tsinghua Super-low Energy Building	Beijing, North China	heat load: 0.7W/m² cold load: 5.2W/m²	0.3	0.3		1.1
2	MOST Demonstration Building	Beijing, North China	Energy saving 70%	0.62			1.363
3	Tianpu New Energy Demonstration building	Beijing, North China	Heat load 30 W/ m2 Cold load 40 W/ m2	0.372			2.0
4	Meiyuan Eco-building	Jinan, North China	15W/m2	0.378-0.407	0.655		2.0
5	Shanghai Eco-building	Shanghai, East China	Energy saving 75%	0.27-0.33	0.16-1.65		1.65-1.82
6	Modern and myriad city·MOMA	Beijing, North China		0.4	0.2		2
7	Wanke Langrunyuan	Shanghai, East China	Energy saving: 20% from envelope, 30% from air conditioner, total saving 50%	1.5	0.8		1.8-3.5
8	Tige Apartment	Shenzhen, South China	Energy saving 58.9％	0.7	0.58		1.6
9	Nanjing Jufuyuan	Nanjing, East China	Energy saving 50%	0.83	0.7		2.6
10	Lang Shi Residential block	Nanjing, east China		0.4	0.4		2.0

Table 10 Technology of low energy consumption buildings case study in China

	Project	Major Energy Technology
1	Helianthus project	− Heat pump and PV system − High insulation and enhance air tightness − Low temperature heating (floor heating) balanced ventilation wit heat recovery
2	Palm Tower Ecobuiling, Nieuwegein	− Thermo-active concrete slabs − Electricity is produced by a façade solar energy system, the CHP and a few small wind turbines − Dry-cooler
3	Primary health care center	− Heat and cold distribution by low temperature radiant ceilings and walls − 10K\kWp PV system − 24 m2 solar water heater − Intermediate ventilation chamber
4	Lummerlund project	− Very high insulation grade − Heat recovery from the ventilation air − Local district heat system feed by combined heat and power (CHP) unit − Towel warmer radiator of 205W with individual thermostat vent − Thermal solar collector − Wind power
5	Llevant project Viladecans	− High efficient heap pumps(COP>3) − High efficient refrigerators − m2 Solar water heater per dwelling − 6 kWp PV system per apartment buildings
6	Solar XXI Building	− High insulated walls and windows − Passive heating and cooling system, − PV system integrated − Solar thermal system − Use of day-lighting and natural ventilation
7	BETEK training and R&D Center	− Reduction of necessary heating and cooling demand via improved insulation measures − Passive solar energy − Heat pump − Solar collector
8	SESAC project, Grenoble	− Solar thermal collector − 8 Mini co-generation unit on natural gas − Biomass district heating for heating and additional domestic hot water − 2.7 MW micro-hydro gerentor
9	Gneis-Moos Housing Estate	− 430 m2 solar water heater with 100 m3 reservior for hot water production and heating purposes − Balanced ventilation − Solar supply 30% of energy consumption
10	Egnahembolaget project Goteborg	− Heat is supplied by passive gain and internal heat load − Balanced ventilation with heat recovery − Heat is supplied by passive solar − 5 m2 solar collector per house for 50% of the hot water supply

Table 11 Insulated performance of the case study in Europe

	Project	Place and climate	U-value			
			Wall	Roof	floor	Glazing
1	Helianthus project	The Netherlands Temperate/sea	Rc: 5.0	Rc: 5.0	Rc:5.0	1.8
2	Palm Tower Ecobuiling, Nieuwegein	The Netherlands Temperate/sea	Rc: 3.5	Rc: 2.5	Rc:3.5	1.2
3	Primary health care center	Barcelona, Spain Mediterranean	0.45	0.45	0.45	1.7
4	Lummerlund project	Kronsberg in Hannover, Germany Middle European	0.11	0.11	0.11	0.83
5	Llevant project Viladecans	Llevant, Barcelona, Spain Mediterranean	0.51	0.41	0.5	1.7
6	Solar XXI Building	Lumiar Lisbon, Portugal Mediterranean	0.3	0.3		
7	BETEK training and R&D Center	Gebze, Kocaeli, Turkey Mediteranean	0.29	0.49	0.45	1.4
8	SESAC project, Grenoble	Grenoble, France Alpine	0.27		0.13	1.2
9	Gneis-Moos Housing Estate	Gneis-Moos, Salzburg, Austria				0.9
10	Egnahembolaget project Goteborg	Lindas near Goteborg, Sweden North European	0.11	0.08	0.11	0.8

3.5 Comparing case study between in China and Europe

1) Scope and scale of demonstration projects

In European, the government and the public pay more attention on low energy buildings and energy efficient buildings. The government issued a lot of strict regulation and codes to promote the energy efficient buildings development, in the mean time, provided a large number of the subsidies to support the demonstration projects on low energy buildings and energy efficiency buildings. In different countries, the support field of energy efficiency buildings is different, for example the passive house in Germany, solar buildings in the Netherlands, High quality buildings in French, and Sustainable House in UK. But, the mainly objectives are same, to reduce the fossil fuel energy consumption of the buildings. And, in 2006, EU energy performance labeling for residential and non-residential buildings was obliged. This regulation will strongly push the demonstration and scaled-up utilization of energy efficiency buildings in EU.

In China, the government also supports some demonstration projects on energy efficiency buildings since late 1990's. Because of the limited budget for the demonstration projects, advanced technology are limited to widely apply in the demonstration project. Because the gap between the R&D and the utilization of energy efficiency technology is quite big, the level of most demonstration projects in China is not very high. China is at the beginning period of the energy efficiency buildings development, demonstration projects are very important to introduce the advanced technology and set up a model building. The demonstration projects on renewable energy buildings were launched in 2006, this is a good message. But, renewable energy technology is just one of building energy efficiency technology, another technology and the comprehensive utilization technology are very import. The most import things for the demonstration projects are the government give some real budget to support the implementation demonstration projects.

2) Insulation level

Table is a list of technology utilized in the case study of China and Europe. This statistics are based on the 10 Chinese case study and 10 European case study, which are conducted by Chinese and international expert. Although these technology information couldn't be full right, but it could represent the general status in China and Europe, some results could be conducted based on the compare of the technology utilized in the case study of China and Europe:

Comprehensive insulated technologies are wide utilized in the EU, and the energy efficiency level of the buildings in EU is obviously higher than that in China. In

European case study, there is a zero emission buildings which is largest low energy building in the world, and there is a super-low energy dwelling houses in Germany. The quality level of other projects in EU is also very average and shows that the general development of low energy building in Europe is very good.

In China, there are two high level demonstration projects. One is the Tsinghua super-low demonstration, which is sponsored by America government and mainly used for testing and monitoring. Another is the MOST energy efficiency demonstration building, which is also sponsored by America government. In these 10 case study, only 5 projects are commercial run project, their U value is much lower than that of the European case study.

3) Utilized of technology type

For the general feeling about these 20 case study, the Europe has moved to the comprehensive utilization of insulated technology and the renewable energy in their building, and the China just began the first step of the energy efficient buildings, enhance the insulated technology. In Europe, most buildings utilize strong insulation technology, low temperature heating and cooling, balanced ventilation system, rain water collect system, heat pump, solar water heater, solar PV and other technology. In China, the major work for the energy efficiency buildings is the building envelop, most projects utilized one or two advanced technology, including solar water heater, heat pump, ventilation system.

Table 12 Technology utilized in the case study of China and Europe

	Utilized technology	China	Europe
1	High level insulation technology	5	5
2	Heat recovery balanced ventilation	5	7
3	Passive solar energy design	1	4
4	Rain water collect system	3	1
5	Solar PV system	4	5
6	Solar thermal system	7	9
7	Heat pump	4	4
8	Wind power generation		2
9	Biomass		1
10	Low temperature heating and cooling		1
11	Micro-hydro generator		1

4. Policy and suggestion

4.1 Existed incentive policy in China

4.1.1 Tax incentive policy

Real Estate Investment Direction Adjustment Tax

Based on the regulation of *China Real Estate Investment Direction Adjustment Tax Temporary Statute* issued by State Department on 16th April, 1991, the adjustment tax of ‘Northern energy efficiency building’ (which is the residence that accords with ‘*Residence building energy efficiency design standard*’) will be zero.

On 20th April,1993, SBRC and State Administration of Taxation issued ‘*Temporary Management Approach of Real Estate Investment adjustment Tax about Northern Energy Efficiency Residence Investment*’(No[1993]653 Document of SBRC) prescribing the detail implementation standard: Any building both tallying with ‘civil building energy efficiency design standard(the part of heating civil building) and adopting new-style wall material or new-style composite wall material will have zero tax rate of real estate investment direction adjustment tax, which had the huge positive impact in the development of promotion of energy efficiency building.

But in Dec of 1999, in order to promote the fast development of economy and carry out the national macro-adjustment policy, Ministry, State Administration of Taxation and SBRC united to issue ‘the Notice about temporary suspending imposition of real estate investment direction adjustment tax’(No[1999]299 of Finance and Taxation), which suspended the imposition of real estate investment direction adjustment tax, then tax policy’s motivation to energy efficiency building disappeared.

Income Tax

Ministry of Finance and State Administration of Taxation issued ‘Notice of favorable policies about enterprise income tax’ (No[1994]001 Finance and Taxation), which prescribed enterprises utilizing coal stone, slag, and powder as the raw material to produce the building material will be exempted of the income tax for five years since the date of operation. The aim of this motivation policy is to promote the resource synthesis utilization, which promoted the development of new-style wall material and limited the usage of emplastic brick.

Value-Added Tax

‘Notice about the exemption of value-added tax of some resource utilization’ issued in

April 1995(No [1995]44) prescribed that the value-added tax will be exempted in the end of 1995 if the building material produced by the enterprises composed of not less than 30% coal stone, stone coal, powder, and the residue in the boiler(not including the residue in the blast furnace).

The notice of value-added tax policy about some resource synthesis utilization and other productions issued in Dec 2001 prescribed that it will execute the policy of drawback immediately after imposition if there are not less than 30% coal stone, stone coal, powder, and the residue in the boiler(not including the residue in the blast furnace) and other residue in the raw material of producing cement since 1st Jan, 2001.Since 1st Jan 2001, it would execute the policy of deduction of half value-added tax to some new-style wall material products; Since 1st Jan 2001,it would impose the value-added tax with suitable rate to the enterprise producing paste brick and tile, which cannot adopt the simple approach to impose value-added tax.

In Feb 2004, Ministry of Finance issued ‘ Complementary Notice about the resource synthesis utilization production value-added tax policy’(No [2004]25 Finance and Taxation), which prescribed that the enterprise in the west area will enjoy the favorable policy of deduction half of the value-added tax not matter which kind of scale it is before 31st Dec 2005 in order to solve the problem that the enterprises in the western area cannot enjoy the favorable policy because of the scale that is too small to reach the requirement in No [2001]198 document.

4.1.2 Launch to implement the Green-building classification system

In March 2006, Ministry of Construction and General Administration of Quality Supervision、Inspection and Quarantine united to issue ‘Green-building evaluation standard’ GB/T50378—2006, establishing the Green-building classification system and motivating the real estate traders to develop and build the high-class green-building. The classification system will be easier for the consumers to know the quality and capability of the building, which will impulse the promotion and application of green-building. This standard began to be implemented since 1st June 2006.However, this standard is only the green-building evaluation standard. Energy utilization and energy efficiency are only one part of Green-building. We have no the classification system of energy efficiency building until now in our country.

4.1.3 Demonstration activities supporting energy efficiency building and renewable energy building

In 1999, Ministry of Construction began to implement the energy efficiency building demonstration. In 2006, Ministry of Finance and Construction began to support the renewable energy building demonstration. The launch of demonstration provided the favorable platform for promotion and application of new technology of energy efficiency building and promote the development of building energy efficiency.

4.1.4 Local incentive policy

According to related national regulation, the local governments issue the provision of 'Consolidated Imposition of city infrastructure matching fee'. Before gaining the license of construction planning, the new or rebuilding or continuation construction projects for industry or civil or public building will be consolidated to impose city infrastructure matching fee in terms of the construction area. In the provision, the projects that the tax could be deducted are listed including the economic building for the mid and low income. Currently some cities have issued the regulation to exempt this fee about the energy efficiency building in order to promote the implementation of Building Energy Efficiency Strategy.

Furthermore some cities also issues the building energy efficiency economy motivation policies, such as issuing the reward and bonus to the energy efficiency building design, free the envelope material Innovation tax for energy efficiency building, carry on the favorable price about the new-style wall material, etc.

4.2 Policy Suggestion and Recommendation

Since the first energy efficient building (EEB) design standard trialed in 1986, China energy efficient building has gone for 20 years, however with unsatisfied result. Major reasons for unsuccessfulness are due to multiple factors. First of all, a complete system of design standards, energy consumption evaluation, and product certification has not been established. Secondly, standard enforcement and supervision under various level of government agencies have been weak, and thirdly, the energy saving in buildings has not directly related with consumer interests with lack of motivation from housing buyers, developers, design organizations, and constructors at many phases of implementing energy efficient building activities.

In order to facilitate applications of renewable energy (RE) and other energy efficiency technologies so as to promote EEB, low energy consumption buildings and RE buildings in China, we propose the following policy recommendations:

4.2.1 Establish a complete system of EEB regulations and management

Legislation can be an effective way of promoting EEB and reducing building energy consumption. In the US, Australia, and many other EU countries, legislation has been used to define the signification and requirement of energy saving and EEB activities.

Under the legal framework, standards, regulations and incentives are made to foster EEB development. For instance, energy bills in the US have been legislated and updated for many times. The EU energy efficiency decrees issued and implemented in 2002 requires its membership countries to make relevant national statutes before January 2006 to reduce building energy consumption in heating, air conditioning, hot water supply and lighting systems.

China's first Energy Saving Law was into effect since January 1, 1998, which marked the countries legal implementation of energy saving campaigns. However, the law is just a conceptual legislation and without its supporting measures and incentive policies, which makes the power of the law weaker than expected.

In recent years, since China has gradually recognized the importance of energy saving and EEB activities, legislation pace has been speeded up. The China Long- and Medium Energy Saving Special Plan was issued in 2004. Modification of China Energy Saving Law was initiated in 2006. The State Council issued in 2006 the Determination on Strengthening Energy Saving Activities Bill (State Council [2006] No. 28), in which EEB is recognized as one of the key EE areas. From these efforts, we can see the national priority in energy saving tasks. Meanwhile, it is also apparent that the energy saving targets for 2006 has not been fulfilled and the energy efficiency has a long way to go and a lot of work to do.

In March 2007, China renewed its Enterprise Income Tax Law. In this law, tax incentives have been provided to the energy saving and water efficient businesses, including reduction of tax payment, duty equality, and other tax reduction policies. This can be considered a state policy towards encouraging energy efficiency in the country. However, specific favorable rates and detailed implementation of the tax law will need further study by the State Council.

Recommendations:

- Speed up the renewal of the Energy Saving Law to make the energy saving management regulations effective by defining clearly the energy saving responsibilities, incentive policies, and necessary penalties. During the law renewal, EEB and its role in reducing energy consumption and contribution in sustained social development should be fully recognized. While considering the EEB current status and requirement, practical and feasible law clause should be made to facilitate EEB standards implementation, piloting, and promotion.
- The importance of EEB should be clearly defined and detailed implementation management regulations should be made and issued. This

will help implementing the EEB targets and tasks regulated in the long- and medium special plans.

- Accelerate the detailed regulations formulation in supporting the Enterprise Income Tax Law. Clarify the incentive mechanisms and policies. Through these incentives to promote development of energy efficient buildings, low energy consumption buildings, and renewable energy buildings in China.

4.2.1 Improve EEB standards and strengthen standards implementation and supervision.

EEB standards are technical foundations for promoting energy efficient building activities. They are also baselines for construction project design, engineering, and evaluation, as well as an importance driving force for various new techniques.

So far, China has issued and implemented a set of technical codes for energy efficient buildings. However compared with those in the developed countries, the EEB standard specifications still have a large gap, with the current 50% energy saving target, there is till 50% more energy efficiency potential.

Furthermore, the EEB standards are poorly implemented. According to a supervision taken by the Ministry of Construction in 2000 on the EEB design standards at Northern China are with heating systems, only 5.7% of the buildings followed the standards. This means that most of the current building projects failed to follow the requirement defined in the Energy Efficiency Design Standards. In the recent years, under a strong campaign by the Ministry of Construction and local governments, the numbers of buildings that designed and constructed according to the new standards become increased every year. By 2006, the proportion of building projects that implemented the national design standards increased to 95.7%, and 53.8% of the projects followed the construction technical standards. Although the newly built projects are basically designed according to energy efficiency principles, the large gaps between blueprint and construction and between engineering and evaluation are still apparent.

Recommendations:

- The most important job for current EEB is to strengthen the EEB standards enforcement, especially in the stage of construction and final evaluation to ensure strict implementation of 50% energy saving target. The enforcement must include that buildings without following the EEB standards will not be allowed to start construction and sales. Jerry buildings in the construction stage must be strictly investigated. Evaluations must be made according to the standards. EEB administrations and quality supervision agencies should strengthen their supervision and penalty. Illegal projects and conducts will be exposed.

- Encourage large cities to implement higher local EEB standards to improve EEB levels at the economy developed areas. For example, Beijing and Tianjin have started to implement a 65% energy saving local targets. Other local government with capability should follow the similar policy to reduce the gap with international best practice. Although China has been equipped with higher standard EEB technologies and products, the current standard system and housing project development pattern constrained people from realizing and perusing the better EEB practice.
- Improve the current standard systems, by clearly defining the part of solar water heaters, heat pump technologies, solar PV systems, and other RE technologies in the EEB application. In the world developed countries such as US and EU, renewable energy contribution is not account into the building energy consumption. Therefore, RE can be a highly recognized means of reducing building energy efficiency. However, China at the current stage has not taken renewable energy out of the building energy calculation.

4.2.3 Establish the building level program and the EEB recognition system to improve public awareness of low energy buildings.

A big obstacle in promoting EEBs is that users have no way to know about building energy efficiency and therefore are not able to choose EEBs. The building level program and the EEB recognition system can be an effective measurement to recognize building's energy efficiency and provide users with the open information about EEB.

Currently there are two methods for building level program and recognition systems: the first method certificate only the high efficiency buildings and focuses on popularizing the advanced technologies and ideals. For example, according to the Passive House program initiated in nine EU countries including Germany, UK, Denmark, the Netherlands, and Austria, only buildings that the energy efficiency are lower than 15kWh/(m2a) can be recognized. The similar programs also include the Netherlands Solar House certificate, French High Quality Environmental (HQE) certificate, and UK's new housing energy consumption certificate just started in June 2007. The second method is that all the buildings need a recognition that indicates the building energy efficiency. Usually there is a minimum building level and only the a building will meet the basic requirement can it start construction. The system encourages house owners and developers to obtain higher level building energy efficiency certificate by minimizing energy consumption and environmental impact. For instance, in the star certification system implemented in Australia, five star buildings have lowest energy consumption and only the buildings above 3.5 star rating can it starts construction.

China initiated its Green Energy Building evaluation system since 2006 and has started assess construction projects according to the system. But building energy efficiency recognition system is still not started.

The building energy efficiency recognition system can reflect building energy consumption levels and its thermal engineering specifications. The recognition on the commercial buildings can help consumers as a reference. This can provide strong guidance to help housing buyers to choose more energy efficient buildings because of they are more healthy, comfortable, and economy. This system will also encourage developers to build more energy efficient housing projects, and in turn drive more energy efficient technologies, building materials, equipment, and relevant technical improvement, and finally result in a favorable environment of EEB development.

Recommendations:

- Enhance outreach and demonstration of green building program. Enlarge the National Green Building Innovation Awards scope and impact, to let more developers and public be aware of what is green buildings so that to promote green building development.
- Actively promote the establishment and implementation of building energy efficiency recognition system. Due to lag condition, studies on establishing a rational housing heat feature index system should be strengthened in order to set up a complete energy efficiency system. A good foundation will help establishment of such a system.

4.2.4 Implement economic incentive polices for EEB development.

Based on international practice, EEB is an area of social benefit. During the early stage of market economy, incentive policies are necessary. In many countries, mandated legal enforcement and economic incentives are used together to encourage and guide EEB development. However, China is applying the EEB standardization as a single mechanism. Currently there are no sufficient pragmatic economic incentives nor fund support. Because the standards are not mandated for either housing developers or consumers who are two principle parts of EEB, effect of energy saving is not apparent. Therefore, China should speed up the process of issuing incentive policies for developers and housing consumers, such as purchase tax reduction, to affect both developers and consumers. Incentives for EEB products are also important. These policies would include tax reduction for encourage technology development, scale production, R&D, and technical improvement, to facilitate fast EEB development.

We would suggest that according to the Enterprise Income Tax Law and the State Council Determination on Energy Saving, financing and tax incentives should be made as soon as possible, which shall include incentive measures for EEB construction, new technology development, product production, sales, and utilization. Specific tax incentive policies may include:

- Residential users: estate purchase tax reduction for buying EEB, green houses, and low energy consumption buildings or apartments.
- Enterprise Users: 50% tax reduction for investing in purchasing environmental protection, energy efficiency, and water saving equipment.
- EEB technology and product producers: for adoption of new building materials for outer wall, high featured building doors and windows, heat pumps, and solar water heaters, etc. :
    - ◆ Value Added Tax: 50% reduction, same with new wall building materials;
    - ◆ Income Tax: Clearly indicate that EEB technologies and product industry is national-support high-tech enterprises, and hence enjoy 15% income tax reduction.
    - ◆ Income tax rebate: encourage enterprises to conduct R&D and technical improvement activities. Investment for these activities can be rebated from income tax.

4.2.4 Issue EEB technology catalog, enlarge pilot and demonstration scope and effect.

The recognition of new energy efficiency technologies needs a process. Pilot and demonstration projects are probably an important way to promote these technologies. Compared with other countries, the EEB new technologies, new materials, and new products are used rarely in China. So far, scientific research has achieved results in ventilation technologies, as well as technologies in sun shadowing, solar water heater, water processing and reusing, earth thermal pump, energy efficient outer wall, doors and windows, central heating, and air conditioning, etc. However, most of these new techs and products are only on academic papers and seldom used in practice. This gap between R&D and practical application hindered their deserved social and ecological values. Therefore, larger scope of piloting and demonstration of these technologies and products will facilitate their marketing and acceptance by construction industry and final users.

The issuance of China EEB technology catalog will help guide the construction industry and users to choose these energy saving technologies and new products, scale up their applications, encourage enterprises to develop more EEB products, and increase the national support on important energy efficient technology development and industrialization.

Recommendations:

- Scale up EEB project piloting and demonstration. Improve outreach to the pilot project achievement.
- Issue the EEB Technology Catalog to provide technical assistance in new product production, application, and promotion.

4.2.5 Accelerate the heat supply system reform and alleviate obstacles for EEB activities in China.

The heat supply, as the largest part in building energy usage, consumes about 40% of the total building energy consumption in cities of China northern area. The unit area heat supply consumes 20kg/(m2 Year) tce., which is 1-1.5 times more than that in the similar climate conditions in Northern Europe.

Besides higher energy consumption, China's current heat supply utility charging system results in less motivation for both developers to apply and users to use energy efficient buildings, which becomes a major obstacles for EEB activities in China's Northern regions. Since levy of the heating cost is based on room areas, instead of actual amount of heat used, this results the same cost for EEB compared with energy wasting apartment. In this system, EEB with less energy consumption has no advantages. Furthermore, most employer organizations provide a certain subsidies or reimbursement so that users have no interest to buy EEB housing and housing developers have no motivation to build higher cost EEBs.

Since 2003, the Ministry of Construction has initiated a pilot of heat supply reform in cities. The 2004 issued "the Technical Guidelines for City Apartment Heating Meters" introduced family based heat metering techniques. However, this reform progresses slowly because of difficulties in housing welfare systems, heat supply infrastructure, metering technologies, and many other factors.

Therefore, only in the condition of successful heat supply system reform and application of family-based charging according to heat usage meter, can EEB recognition be widely accepted, EEB motivations aroused, and EEB activities conducted smoothly.

Recommendations:

- Speed up the heat supply system reform at China cities. Implement heat charging system according to usage meters, and replace the employer paid subsidies with that includes the subsidies into salary and pay by usage.
- Study on issues of family-based charging and resolve the relevant technical problems.

4.2.6 Improve public awareness of EEB and obtain broader support.

Unawareness and lack of access of information on EEB can be a key factor hindering energy efficient building development in China. Except few specialists, the public has limited knowledge on EEB advantages. They obtain some concept only from developer's advertisement or unfair promotion. Due to this unawareness, most are unwilling to purchase EEBs, which makes EEB activities difficult. Therefore, effective information dissemination and popularization becomes necessary. Only when the importance of EEB and its long-term benefit are widely accepted by developers, governmental organizations, and the public, can the EEB be developing more progressively.