KTH Industrial Engineering
and Management

Comparison of Chinese Green Building Standard with Western Green Building standards

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Abstract

With rapid economic growth and urbanization in China, the Chinese building sector now accounted for a large amount of its energy usage and pollution. In order to minimize the environmental effect, the Ministry of Urban and Rural Development (MOHURD) has set a goal that 30% of all new constructed buildings will be green by 2020.

This report reviews the Three Star System, the Chinese green building standard developed by the government agency MOHURD in order to promote and regulate green buildings in China. The study is done by comparing the Three Star System with two of its western equivalents, BREEAM and LEED. The technical manual of each standard is studied and compared, results from various researches within the area is also featured in the report.

The finding of this report is that Three Star System is necessary to fulfill Chinas unique situation with a building sector that consist of high rates of new construction, although the standard is necessary it still need improvement in technical detail and user-friendliness to be at the same level as LEED and BREEAM. Some suggestion are proposed in the report for further development of the Three Star System

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1 Introduction

China has experienced rapid economic growth since the late 20th Century and its building sector and energy usage has also grown rapidly. In 2010 China built as much housing as the total housing space of Spain or roughly four times the total housing space in Sweden, in just one year as shown in Figure 1. Today China and USA are the two countries with the highest level of energy usage in the world and buildings accounted for a huge part of it, on an annual basis building in the USA consume 39% of USA's total energy use, 68% of the total electricity consumption, 12% of the total water consumption and 38% of the carbon dioxide emissions (EPA, 2009). There are not official statistics for the amount of energy the Chinese building sector uses but a few studies suggest that in 2009 construction accounted for roughly 40% of Chinas total energy use from a life cycle perspective (Switchboard, 2010). This highlights the importance of increasing the energy efficiency in the life cycle of a building, from construction to operation and demolition, to achieve this green building standard can be used in the control the performance of a building.

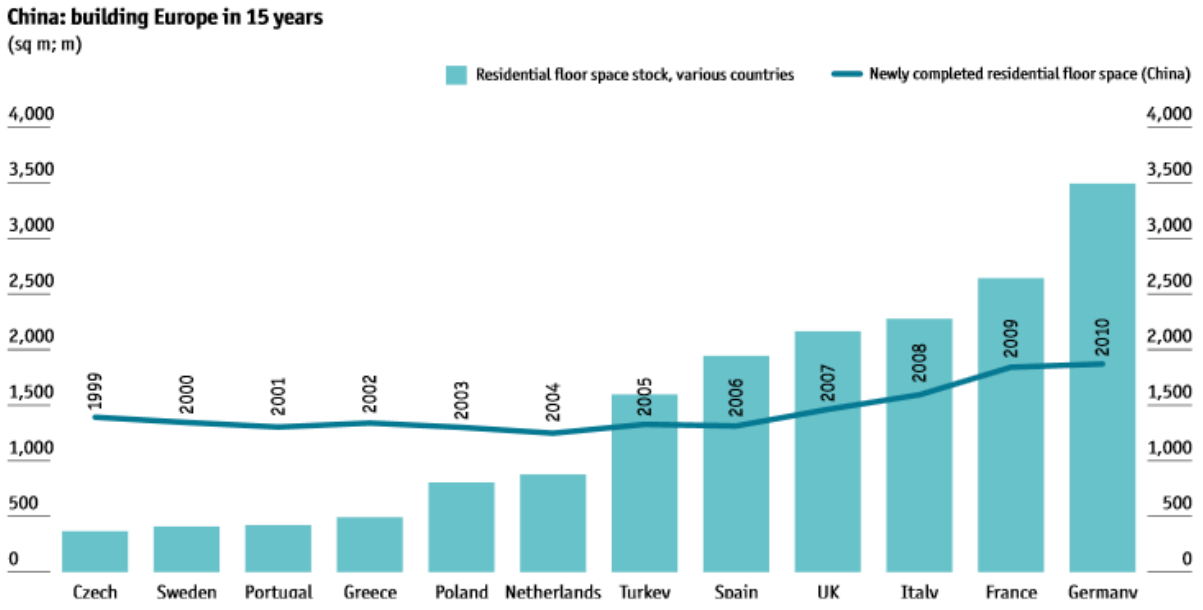

Figure 1. Construction rate in china in comparison with total floor space in selected countries (The Economist Intelligence Unit, 2011)

Conventional building design are largely focused on factors such as of utility, durability, comfort and economy, green building expands and complements these aspects with factors such as the environmental and resource-efficiency through the life-cycle of the building from siting to design, construction, operation, maintenance, renovation and deconstruction. Certified green buildings can often be sold or rent out for a higher price than conventional and at the same time reducing

the environmental impact of the building and the operating cost for tenants over a longer period. (Chegut, et al., 2013)

Many countries and organization have developed their own green building standards in order to regulate, evaluate the performance of green buildings and promote the construction of green buildings. Two of the most widely used standards are LEED (Leadership in Energy and Environmental design) from USA and BREEAM (Building Research Establishment's Environmental Assessment Method) from UK. Studies have shown that on average a LEED certified building was 25-30% more energy efficient than ordinary buildings and over a 20 year period (R.Newsham, 2009) and many green buildings have returned 570 to 765 USD per square meter back on initial investment (Langdon, 2007).

1.1 Green building in China

In 2005 China received its first gold rating by LEED, a program designed by the US Green building council to evaluate green buildings and the interest for green building in China has been increasing since then. In 2006 the Three Star System systems was introduced by the Chinese government agency, Ministry of Housing and Urban-Rural Development (MOHURD) in order to regulate evaluation on green building and promote the construction of green building. The Three Star System is a standard mainly for evaluating large residential buildings and public buildings.

Although the Three Star System was only introduced in 2006 it has grown to become one of the most popular green building standards in China today in terms of projects in progress, as shown in Figure 2. Three Star System is likely to gain even more popularity in the coming years due to ambitious government policies made for the 12th Five-Year plan for the years 2011-2015 in order to combat many of the environmental problems in Chinese cities such as the smog in Beijing, CO_2 – emission, polluted land and water shortage many areas (The Economist, 2013), in 2012 MOHURD set a targeted, stating that 30% of new construct buildings in China will be green building by 2020 (Green Prospect Asia, 2012).

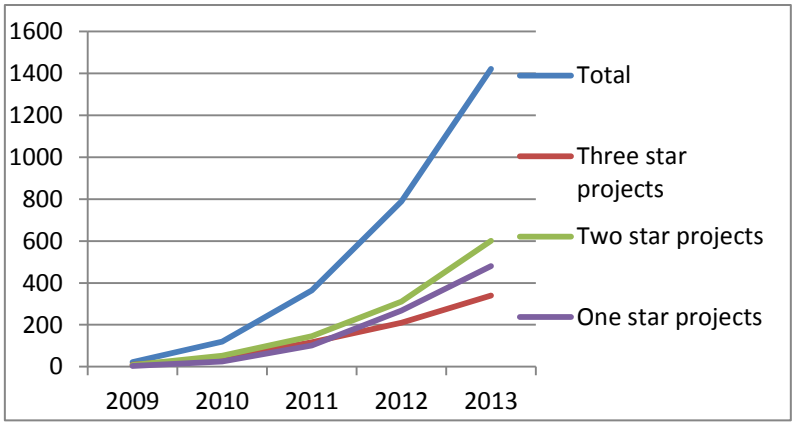

Figure 2. Growth of Three Star System projects in China

In order to create the economic incentive of constructing a green buildings, the Chinese government grants subsidies to buildings with two star and three star with 45 RMB per sqm. and 80 RMB per sqm. respectively (Green Prospect Asia, 2012).

One of the issues of green buildings in China is that a majority of the green buildings in China are in provinces with wealthy tier 1 or tier 2 cities such as Shanghai, Suzhou (Jiangsu), Shenzhen (Guangdong) and Beijing as shown in Figure 3, these four provinces together account for 50% of the total number of green building certifications in China (Green Building Map of China, 2014) but only 17% of the total population.

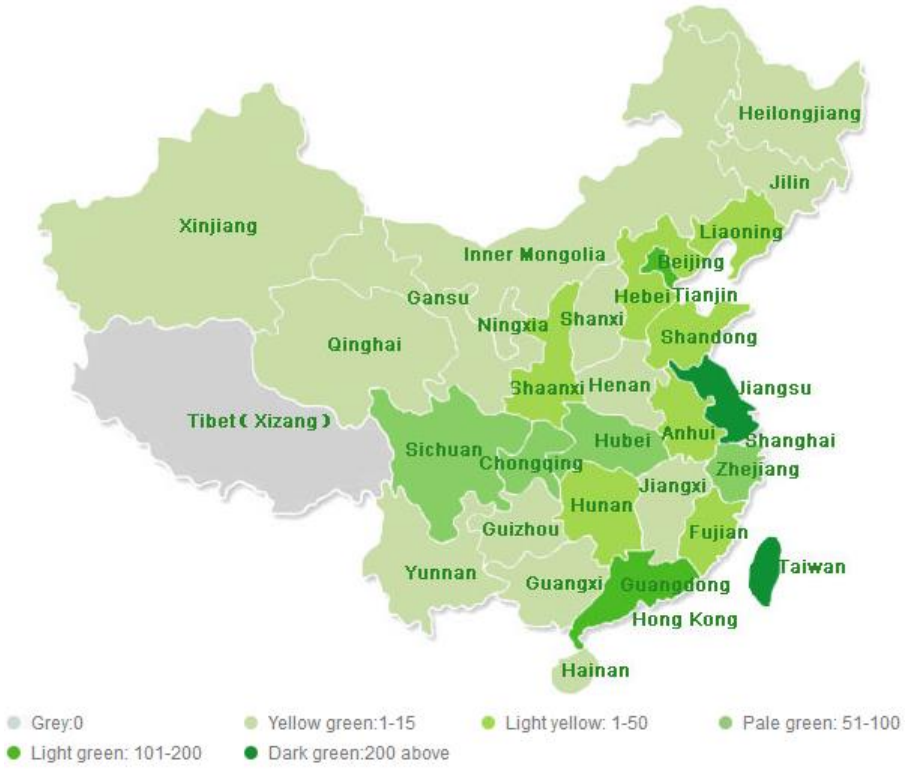

Figure 3, locations of green buildings in China (Green Building Map of China, 2014)

1.2 Research Questions

This report will attempt to answer the following questions:

- What are the benefits of constructing a green building compared to conventional buildings?
- What are the benefits for tenants of a green building in terms of economic gains, comfort and convenience?
- What are the main gains and disadvantages of Three Star Systems and what can be improved?
- How much future market potential does Three Star System have compared to the other standards?

1.3 Methodology

This report will brief the reader with a study of the three green building systems mentioned previously, the reader will be presented with background information about the system, how the assessment works and what aspect are assessed in respective systems.

In order to answer the research questions, research results from various institutes, online articles and journals will be used in this report. The assessed items will be broke down to five categories, namely energy saving, resource utilization, comfort & health, environment and others. Comparisons between the green building standards will then be made in order to find possible improvements for Three Star System.

Figure 3, a blockdiagram of the project process

1.4 Limitations

BREEAM and LEED can be used to evaluate most type of building projects while Three Star System can only be used to evaluate new constructed public or residential buildings, therefore this report will be comparing building schemes for new constructed residential building projects, public building, renovations of in-use building will not be considered.

Both BREEAM and LEED are used internationally and there are various different assessments plans for different countries or regions. This report will only use the assessment plan featured on

BREEAM and LEEDs official website as examples for score distribution and assessment areas and technical requirements.

Large part of the data and information used in this report are taken from studies and articles found on the internet. BREEAM and LEED being the older and managed by third party organization have been more researched on while researches regarding Three Star System have been lacking. For example, no studies in English were found regarding the energy efficiency of buildings using Three Star System.

2 Three Star System

To promote and regulate the development of green buildings, the government department MOHURD released a national green building evaluation standard in 2006. The standard can be used to evaluate new constructed residential buildings or public buildings such as work office, supermarket or hotel buildings. Three Star System grants two different certifications, design label and operation label. Design label is a pre-certification that can be granted to allow the project to market itself as a green building. Operation label is final certification that is granted after controlling the energy performance of the building after one year (Yong Geng, 2012). As of 2014 there are roughly 1500 buildings in China certified by the Three Star System out of which only 107 had the operation label. (Green Building Map of China, 2014). The growth of demand in green buildings has largely been fueled by government policies and targets.

The Three Star System has six technical aspects as shown in Table 1, the technical aspects can be categorized further into control items, general items and preference items, control items are requirements that the projects have to fulfill as prerequisites, the amount of control item to be satisfied is shown in in *Table 1*. Certain numbers of general items has to be fulfilled in order to receive one- or two stars, to achieve three stars certain amount of preference items has to be achieved as shown in *Table 2*. There are in total 76 items for residential buildings, including 27 control items, 40 general items and 9 preference items (MOHURD, 2008).

Table 1, numbers of control items to be fulfilled before grade classification (MOHURD, 2008)

	Land saving and outdoor environment	Energy saving and energy utilization	Water saving and water resource utilization	Material saving and material resource utilization	Indoor environment quality	Operating management
Residential	8	3	5	2	5	4
Public	5	5	5	2	6	3

The evaluation process and certification of buildings are managed by MOHURD. Under its supervision there are roughly 30 local authorities that carries out the evaluation of one- and two star projects together with local Universities. The three star projects are evaluated on national level by MOHURD. The evaluation procedure includes submission of application, formal examination, expert committee evaluation and public scrutiny where anyone can submit objections to the project (Ling Ye, 2012) after the process, projects will receive a rating of one-, two- or three-stars depend on how many general and preference item a project has achieved.

Table 2. Item requirement for grade classification of residential building (MOHURD, 2008)

Grade	General Items and Preference items (Total: 49 Items)						
	Land Saving and Outdoor Environment (Total: 10 items)	Energy Saving and Energy Utilization (Total: 8 items)	Water Saving and Material Resource Utilization (Total: 7 items)	Material Saving and Material Resource Utilization (Total: 9 items)	Indoor Environment Quality (Total: 7 items)	Operating Management (Total: 8 items)	**Preference Items (Total: 9 items)**
★	4	2	3	3	2	4	-
★★	5	3	4	4	3	5	3
★★★	6	4	5	5	4	6	5

The evaluation process of Thee Star System offers provincial flexibility with regard to local condition, climate and environment. If an item is not compatible to the regions geographic or climate condition it can be left out of consideration, for example requirements on central heating systems are not applicable for projects in southern China due to the warm climate. The total items for evaluation are then reduced correspondingly and a new requirement for grade classification can be determined with regard to the original scale adjustment.

3 BREEAM

BREEAM was developed 1990 by the BRE (Building Research Establishment) based in UK. Since then, the standard has been updated many times, the latest major update to the standard was in 2011. Today more than 250 000 buildings and 15 000 projects around the world have been certified by BREEAM which makes it one of the most used standards in the world (BREEAM, 2013). Certification by BREEAM is processed by professional BREEAM assessors, it is encouraged to appoint an assessor at the early design stage so the assessors can help and give recommendations in the early design stage to let the project achieve the desired rating cost effectively. The BREEAM certificate is given to the building once the construction is complete if all requirements are satisfied and energy efficiency is confirmed by computer modelling.

BREEAM can be used to certify almost every kind of building and it has many assessment schemes to do so. BREEAM has local adaptations in countries such as UK, Germany, Netherlands, Norway, Spain, Sweden and Austria, countries without local adaptations of BREEAM can use one of the four BREEAM International schemes listed in *Table 3* (Olsson, 2013).

Table 3, list and description of the four BREEAM International schemes

Scheme name	Description
BREEAM International New Constructions	Used to certify new commercial or residential buildings. The scheme can be adapted to support local best practice codes and standards
BREEAM International Refurbishment	Used to certify buildings that has undergone renovation
BREEAM In-Use International	Used to assess and improve the performance of existing buildings
BREEAM Communities Bespoke International	Used to certify a community-scale project

Each of the four schemes has its own manual with large amounts of technical details, the distribution of credits between the categories and details regarding the assessment. The technical details are divided into 10 categories, each category has mandatory requirements that has to be fulfilled in order to obtain the final certification. Most of BREEAM schemes consist of the ten categories listed in *Table 4*.

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Table 4, description of areas assessed in BREEAM schemes.

Categories	Description
Management	Promotes responsible construction practice and environmental planning
Health and Wellbeing	Evaluated comfort, water quality and safety access
Energy	Promote better building energy efficiency monitoring and use of renewable energy
Transport	Evaluates public transport accessibility, proximity to amenities and cyclist facilities
Water	Evaluates water consumption, leak detection and water recycling
Materials	Evaluates life cycle impact, insulation of material optimization
Waste	Evaluates construction waste management, use of recycled material and waste storage
Land Use	Evaluates site selection and ecological impact
Pollution	Evaluates light and noise pollution, refrigerants from building systems and NOx gas emission
Innovation	Promotes innovation within the construction industry and recognize benefits not rewarded by the other categories

BREEAM uses a point based score rating with a percentage weighting system, for example if a project achieves 5 out of 10 points the energy, the project receives a percentage score of 9.5% from the energy category. Each category is calculated and added up, the highest possible score is of course 100%. The weighting system allows BREEAM to adjust the requirements of according to local priorities. An example of the credits weighting for BREEAM International New Constructions can be seen in Figure 4.

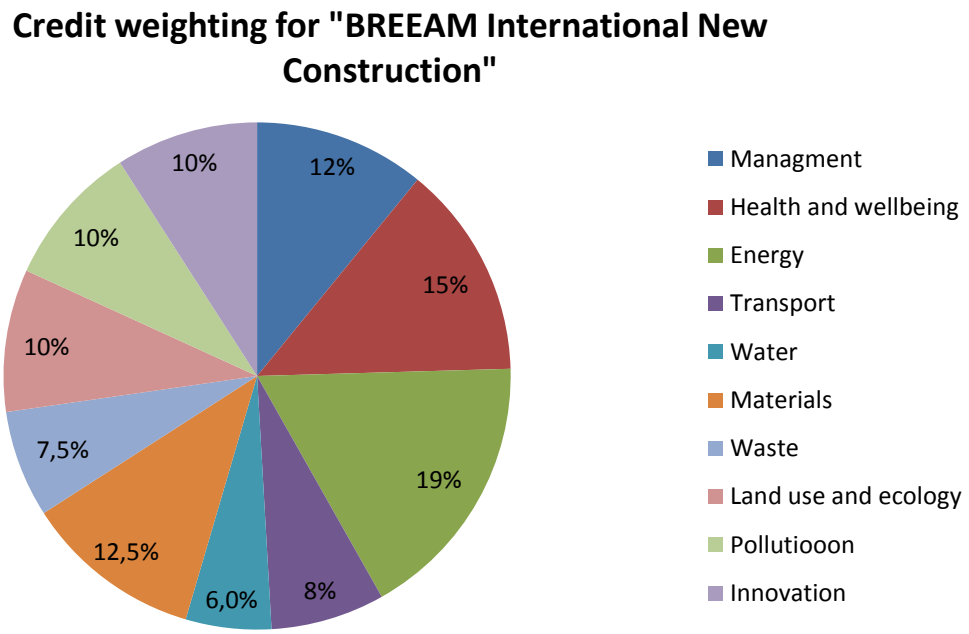

Figure 4, example of a credit disbrution for a BREEAM scheme (BREEAM Manual, 2014)

BREEAM has six levels of classification, Pass, Good, Very Good, Excellent and Outstanding, the rating benchmark is showing in *Table 5*. To achieve the outstanding rating a project has to be re-evaluated after a year (BREEAM Manual, 2014).

Table 4. BREEAM classification levels benchmark. (BREEAM, 2014)

Grade	**Percentage score required**
Pass	30-44%
Good	45-54%
Very Good	55-69%
Excellent	70-84%
Outstanding	85-100%

4 LEED

LEED was created to provide a national standard in the US in 2000 by the US Green Building Council (USGBC) and has expanded its influence around the world. Today LEED is one of the most commonly used green building rating standard around the world having certified over 50 000 projects (LEED, 2014) and there are local adaptations of LEED in many countries.

The most recent version of LEED was released 2013, currently the rating system includes five main group that consists of 10 rating schemes as shown in *Table 5*, these schemes can be used to certify residential buildings, public buildings, major renovations and retrofitting of existing buildings.

Table 5, list and description of LEED schemes currently in use.

Rating schemes	Description
• LEED For New Construction and Major Renovations • LEED for Core and Shell • LEED for Schools • LEED for Healthcare • LEED for Retail	Certifies new constructions or building that has undergone major reconstruction by one of the fem systems in the main category
• LEED for Commercial Interiors • LEED for Retail Interiors	Certifies the interior of buildings used by the tenant
• LEED for Existing Buildings: Operations and Maintenance	Certifies existing buildings that are undergoing improvement work with little to no construction
• LEED for Homes	Certifies multifamily or single family retrofitting projects
• LEED for Neighborhood Development	Certifies new land development projects or redevelopment projects containing residential uses, nonresidential uses or a mix

LEED For New Construction scheme is equivalent to the Three Star System and can be used to rate public and residential buildings. The scheme uses a credit system to determine the classification level of the project. The total possible credits a project can amass is 110, of which 100 are basic credits, 6 credits can be given for Innovation and Design and another 4 credits can be given for Regional Priority. The credits are given out in the 8 categories listed in *Table 6*.

Table 6, list of credit categories and description for LEED For New Constructions. (LEED Credit Library, 2014)

Main credit categories	**Description**
Location & transportation	Promotes smart site selection and accessibility to transport
Sustainable site	Promote sustainable building practice and reduction of light, heat and noise pollution
Water efficiency	Promote smart use of water and water efficient landscaping
Energy and atmosphere	Promote better building energy performance, use of green power and renewable energy
Material and resources	Promote use of sustainable building material and reduce waste
Indoor environmental quality	Promote better indoor air quality and access to day light
Bonus credit categories	
Innovation in design	Encourages innovative design measures not covered under the five main categories
Regional priority	Encourages projects to take in consideration regional environmental priorities

The number of credits that can be obtained in each area can vary across different LEED schemes, the distribution of 110 points for LEED For New Construction can be seen in Figure 5.

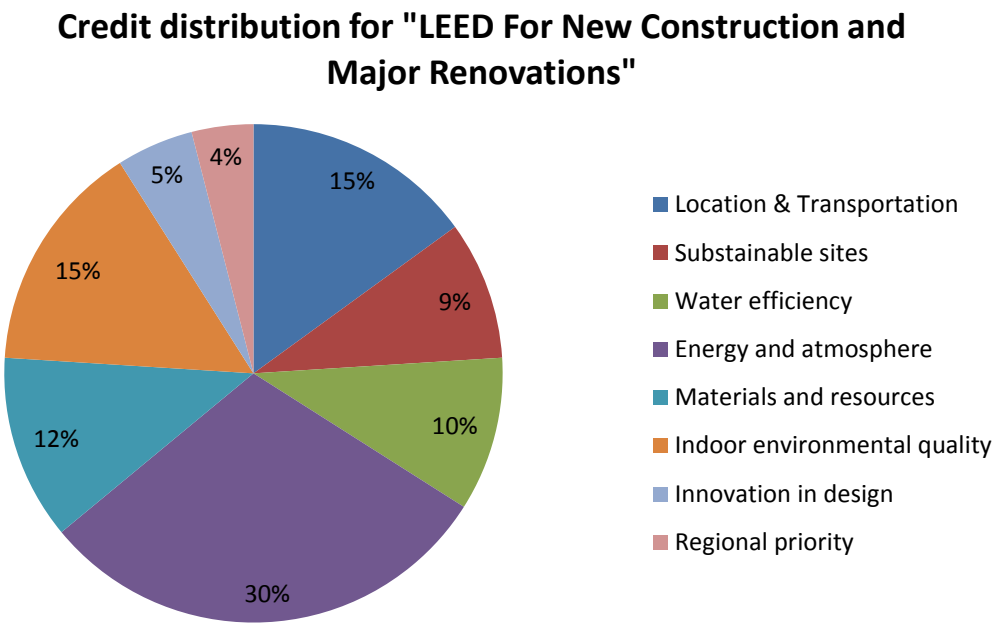

Figure 5 Example of credit distribution for a LEED system. (LEED, 2014)

The grade classification is based on the total number of credits a project achieves not considering the category of the point, this means that a project with same certification level can have very difference green performance and it has been possible to focus on the 'easier' credits in order to get a certification, so called 'Green washing' (Archdaily, 2013). On the other hand, this would still encourages projects to do what they can to make the building greener than a conventional building and often times this leads to little or no additional cost for the property developer (Langdon, 2007). In the latest version of LEED some of these issues have been addressed by introducing more prerequisites especially in the Energy and Atmosphere category.

The lowest classification is Certified, a minimum of 40 points must be achieved to receive this rating. The other four rating levels are Silver, Gold and Platinum in ascending order. The number of credits to receive each classification is shown in *Table 7*.

Table 7, points required to achieve each certification level in LEED.

Grade	**Credits Required**
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80

5 Breakdown and analysis

Three Star System, BREEAM and LEED have a lot of things in common but also a lot of differences. This part of the report will breakdown the assessment categories of the schemes for residential buildings from each of the three standards and compares a selection of technical requirements to each other. The assessment categories of each green building standard have been sorted five areas, namely energy saving, resource utilization, comfort & health and environment and others.

The assessment plans that have been chosen to be looked into are Three Star System for residential buildings, BREEAM New Constructions and LEED For New Constructions. The Three Star System for residential and public buildings share similar features. BREEAM New Constructions and LEED For new Constructions have been chosen since they are BREEAM and LEED's counterpart to Three Star System for residential buildings. Point distribution of the three standards after being sorted into five categories are shown in Figure 6, the details regarding each category will be looked into further into the report.

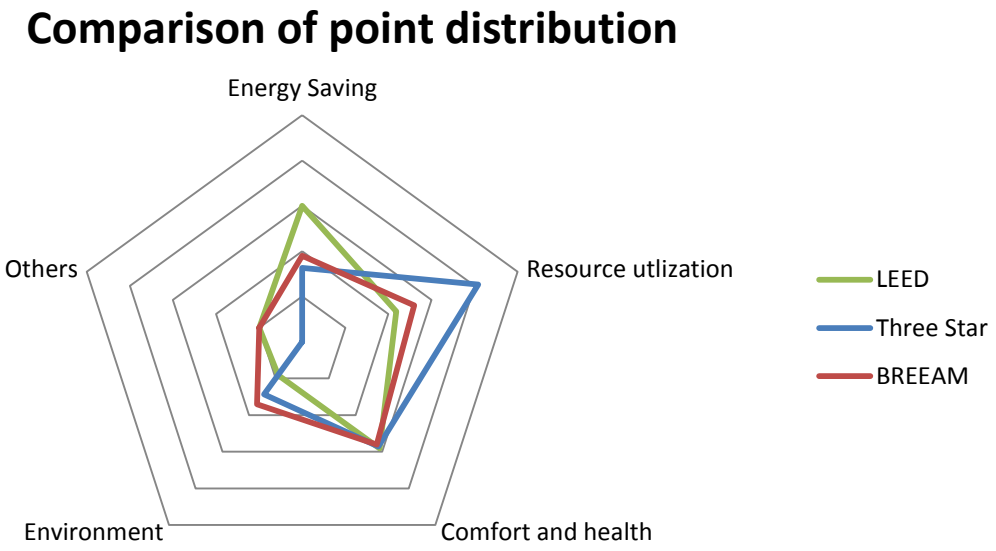

Figure 6, point distribution of the three green building standards after being sorted into 5 categories.

5.1 Certification process

One of the main differences between three standards is the process of achieving a certification, Three Star System only grants the operational certification a year after completion in order to confirm the energy efficiency has been achieved while BREEAM and LEED can grant the certification upon completion if modelled energy efficiency performance fulfills the requirement. While the system Three Star System uses truly confirms the energy saving efficiency of a building,

it has a few flaws, for example it implies that projects has to wait at least for one year in order to receive government subsidies for green building since the subsidies is only granted upon completion (Green Prospect Asia, 2012). It also entirely removes the economic incentive of pursuing an operational certification since the building would have most likely been sold or rented out after a year and this might be one of the reasons why only 6% of all Three Star System projects have operational certification.

A fix to this problem might be to use policies similar to BREEAM and LEED, simply by granting certification upon completion with approved modelled energy efficiency, this grants more economical incentive since the building would be able to market itself as an operational green building. In order to make sure the real energy efficiency is achieved Three Star System could introduce compulsory energy monitoring managed by a third party with frequent performance check.

Both BREEAM and LEED grants different amount of points for an item depending on the difficulty of the item, Three Star System would also benefit from using such system instead of the current one item one point system. This would make it harder to projects to pursue the 'easy' items and do as little as possible to achieve the certification.

5.2 Technical manual

Three Star Systems technical manual lacks detail, requirements to fulfil each item are briefly presented with no information of the aim of the requirement and assessment criteria are lacking for a few items. Both BREEAM and LEED have detailed technical manuals publicly available with aim, assessment criteria. LEED also has a resource site with examples of project that has fulfilled the requirement also a forum for further discussion and questioning. By improving the user-friendliness of Three Star System would benefits smaller property developers without the finance to hire professional green building consultants to pursue green building label.

5.3 Energy saving

Energy saving is one of the main goals of using green building standard. Reducing the use of energy is beneficial in terms of lower economic costs and less greenhouse gas emission. There are mainly three ways to achieve this, by improving energy efficiency, use of renewable energy and monitoring of energy usage as shown in *Table 8*. There has been a controversy regarding the energy performance in green buildings but most of the researches done suggest that buildings built with green building standard does indeed improve the energy performance of the building (R.Newsham, 2009) (PNNL, 2009).

Table 8, comparison between a selection of requirements for energy saving.

Topic	Three Star System (residential)	BREEAM New Constructions (residential)	LEED For New Constructions v4
Energy efficiency	The energy efficiency ratio has accord with the Chinese national standard	Either by BREEAM's own calculation standards, ASHREA or approved local building standard	Requires a minimum of 5% energy efficiency improvement compared to the baseline performance rating (can be based on local standard) or ASHRAE standard
Renewable energy	Amount of renewable energy in proportion of total energy consumption must exceed 5%	Encourages feasibility study for using local low or zero carbon energy source, the study has to be carried out by an energy specialist	Encourages use of renewable energy and grants points starting from 1% of total energy consumption
Energy usage	National standard GB 50189-2005 has to be fulfilled	Encourages monitoring of energy consumption through use of energy display devices in order to create awareness	Requires energy monitoring in order to identify opportunities for additional energy saving. Also required to share energy consumption data with USGBC

The standard regarding energy saving is quite similar for these three system each referring to the local building standard and encourages projects to exceed the efficiencies of the local standard. The main difference being that LEED requires energy monitoring as a prerequisite while

BREEAM grants points for monitoring and Three Star System has one general item for monitoring.

Studies suggest that energy usage of a building can be reduced by monitoring in real time (Batista, 2014), this is beneficial both to the tenant and property owner is terms of lower electric bills and the environment.

5.4 Resource utilization and management

This category is especially important for the Chinese market since a huge amount of the buildings in China are newly constructed, in 2009 construction accounted for roughly 40% of Chinas total energy use and according to some reports by 2030 around 70% of China's population will be living in the city (The Economist, 2014), there are no clear signs that the number of new constructions will experience a large decline in the near future. Energy can be saved by sourcing the construction material in a correct way, *Table 9* shows the requirements on construction material and also water efficiency.

Table 9, comparison between a selection of requirements for resource utilization and management.

Topic	Three Star System (residential)	BREEAM New Constructions	LEED For New Constructions v4
Construction material	70% of the material used must be produced within 500 km of construction site and 10% of total weight of material shall be recycled	Uses life cycle assessment to measure the impact of materials and calculates a score using BREEAM Mat 01 calculator.	Encourages use of life cycle assessment to pick materials with preferable environmental, economic and social impacts.
Construction waste	Encourages usage of reusable or recyclable materials.	Encourages monitoring of waste and various measures in order to avoid landfill or incineration of waste	Requires a construction and demolition waste management plan in order to efficiently recover, reuse and recycle waste materials
Water	The water saving rate shall not be less than 8% compared to the baseline standard	Compares the water efficiency of the building (calculated with BREEAM standard) to a baseline performance	Encourages reduction in water consumption by metering and recommending liter per flush and water pressure for different appliances

As shown before in Figure 6, Three Star System has a lot of focus on resource utilization. The Three Star Systems policy regarding construction material might not be the optimal for decreasing energy usage. Currently the policy only take in two factors, the material has to be produced within 500km and 10% of the total material has be have been recycled, factors such as harvesting of raw material, production process of the material and waste handling would also have been included if LCA was used as a requirement instead.

By limiting the distance materials has to be produced within also increase the cost of constructing green buildings in rural areas due to lower supply of locally produced materials in these areas.

5.5 Comfort & health

Comfort and health is an important aspect of green buildings and contributes to the wellbeing and convenience of daily activities of the tenant in form of proximity to public transport, noise reducing measures and providing recreational green space, as shown in *Table 10*.

Table 10, comparison between a selection of requirements for comfort and health.

Topic	Three Star System (residential)	BREEAM New Constructions (residential)	LEED For New Constructions v4
Transport	Walking distance from entrance of residential quarter to a public transport network shall exceed 500 m	Has an index that take in factors such as distance to public transport node and average time of service at the node. Also encourages alternative transport such as carpooling and electric cars	Encourages use of green vehicles and bicycles. Requires a public transport stop to be within 800 meters of the residential quarter
Noise reduction measures	WASRF shall not be less than 45dB for wall and 30 dB for window	Requires an acoustician to be appointed during the design stage	Encourages use of a LEEDS or local building standard for requirement on reverberation time, sound isolation and reducing HVAC background noise
Green space	Green area must be greater than 30% of ground area and not less than $1m^2$ per capita	Promotes measures in order to enhance and preserve the ecology of the area	30% of the total site area must be outdoor space and 25% of outdoor space must be vegetated
Thermal comfort	Design has to be fulfill the national standard GB50176	Encourages thermal modelling with ISO standard	Promotes thermal comfort design with ASHRAE Standard 55-2010, ISO 7730:2005 or CEN Standard
Air quality	Encourages installation of indoor air quality monitoring device.	Prohibits use of asbestos and encourages use of natural ventilation. Air quality should meet WHO guideline standards	Prohibits smoking inside building. Ventilation shall meet the minimum of relevant local standard

Survey and studies suggest that green buildings does not have significantly better in-door environment nor improves productive of offices (Gou, 2012). However, this does not conclude that there are no beneficial health factors to the tenant from staying in a green building. Green buildings certainly has better outdoor environment compared to conventional buildings with requirements for minimum green space and proximity to public transport node.

5.6 Environment

The growth of China in the recent decade has largely been at the cost of its environment and natural resources, problems such as smog, polluted soil and water is a common problem in China. Therefore Three Star System requires measures to be taken in order to decrease pollution especially caused by construction sites, a selection of other issues are also reviewed in Table 11.

Table 11, comparison between a selection of requirements for environment.

Topic	Three Star System (residential)	BREEAM New Constructions (residential)	LEED For New Constructions v4
Land usage	Land use per capita has to be less than between 15m^2 and 43m^2 depending on the height of the building. Low rise buildings are allowed to use more land area	The ratio between total floor space area and foundation area should be greater or equal to 3:1	Not specified
Heat-island effect	Heat island effect shall not be higher than 1.5 degree	Not specified	Encourages use of energy generating systems and use of material with high reflectance
Greenhouse gases	Not specified	Discourages use of refrigerants	Forbids use of CFC-based refrigerant and discourages use of refrigerant
Pollution	Requires actions to be taken to reduce pollution of the construction site. Noise, air, water and light pollution will be checked during construction upon completion	Encourages measure to be taken in order to prevent pollution of building site.	Requires actions to be take in order to control soil erosion, waterway sedimentation and airborne dust

Unlike BREEAM and LEED, the Three Star System has requirements for land use per capita, this is especially important for building construction in large Chinese cities in order to address the issue of land shortage in areas as population increases (New York Times, 2013).

Researches points out that Heat-island effect from urban area increases rainfall to some extent and increases the production of pollutants such as ozone (UCSUSA, 2011), this problem is addressed in form of a maximum permitted heat-island temperature of 1.5 degree.

While BREEAM and LEED grants credits for not using refrigerant, Three Star System lack policy to regulate use of refrigerant. Use of refrigerant may increase the amount of greenhouse gas in the atmosphere and ozone depletion, therefore should be regulated.

6 Discussion and conclusion

It has been established that green buildings are more energy efficient and has less environmental impact compared to conventional buildings, but studies does not suggest that the indoor environment in green buildings are significantly better than conventional buildings. Green building can be very economic beneficial compared to conventional building for the property owner in form of higher rent and sales price, tenants can also gain from staying in a green buildings since the energy and usage are usually lower than a conventional building.

Three Star System, BREEAM and LEED are similar to each other in many ways, Three Star System refers many times to national standards in many areas for detailed regulation requirements, both BREEAM and LEED permits use of accepted local standards but also has their own standard. Although the Three Star System is fully functional as a green building standard it still has room for improvement, here are suggestion for improvements in a few areas:

- Only roughly 6% of the certified building has operational certification, the economic benefits are huge for achieving design status in terms of marketing sales while operational certification grants close to zero economic benefits but all the environmental and energy saving benefits for the tenant. A major road block for achieving operational certification is the one year waiting time for certifying, instead operational certification should be granted upon completion of construction if the building passes the energy saving requirement with data based on modelling and compulsory performance checks should be performed every year to confirm data if the building want to maintain the certification.
- Regional distribution of Three Star System is very uneven, 50% of all the green building labels are in four provinces that has 17% of the population. Local governments in other areas also need to encourage construction of green building by advertising or subsidizing green building projects.
- Three Star System need to implement more assessment schemes that covers more than just residential and public buildings, a green building standard for old buildings would allow Three Star System to target a much larger market segment. Retrofitting old construction with energy efficient renewable energy sources (such as solar heating for warm water etc.) and energy use monitoring would help to cut energy costs.
- LEED excels in user friendliness compared to Three Star System, LEED has detailed description of every assessment item on it's website with forum for discussion and examples of projects that has achieved the item. Three Star System would need a similar

system of its own in order to promote easier access of information, this would encourage smaller property developers with limited resources to pursue green building certification.

- Three Star System need to improve the technical coverage of the policies, for example the construction materials are only required to be produced within 500km radius of the construction site and does consider the whole life cycle of the material, policies regarding use of refrigerant that contribute to greenhouse gas is not specified either.
- A weighting system or credit system of the categories would make it harder for projects to pursue the easy items and do as little as possible to achieve the certification

In some ways Three Star System has more market potential in the China compared to BREEAM and LEED, Three Star System is supported economically by the Chinese government, controlled by the government agency MOHURD, it is designed specifically for China and addresses more of Chinas local environmental and energy demand such as high energy demand in the building sector, land- and water shortage.

The government and MOHURD play a central role in the development of Three Star System, in order to further develop the standard, government may consider adding more schemes to the standard in order to encourages retrofitting of existing buildings. The lack of operational certifications is also a huge problem that has to be dealt with. Although the Three Star System has already largely successful, it can still do more to help China decrease energy usage and reduce pollution.

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