Journal of Cleaner Production 64 (2014) 646–653

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Educational initiatives

Development of green campus in China

Hongwei Tan [a,b,c,*], Shuqin Chen [a,b], Qian Shi [d], Lingling Wang [a,d]

[a] Research Center of Green Building and New Energy, Tongji University, 1239 Siping Road, Shanghai 200092, China
[b] China Green University Network, 1239 Siping Road, Shanghai 200092, China
[c] UNEP-Tongji Institute of Environment for Sustainable Development, Tongji University, 1239 Siping Road, Shanghai 200092, China
[d] School of Economics and Management, Tongji University, 1239 Siping Road, Shanghai 200092, China

ARTICLE INFO

Article history:
Received 5 June 2013
Received in revised form
5 September 2013
Accepted 10 October 2013
Available online 22 October 2013

Keywords:
Green campus
Sustainable development
Energy and resource efficient campus
Low carbon

ABSTRACT

The higher education is experiencing a rapid development in China, with the sharp increase of energy use and the low level of campus facility operation. Meanwhile, with the responsibility for knowledge transformation, sci-tech talents cultivation and technical innovation, universities are of great importance in the development of the sustainable society. The initiative of green campus has attracted great attention from both the society and the universities themselves. Therefore, it is very meaningful to get a full understanding of the current status of green campus development in China, and make the feasibility planning for the next step on this base. In this paper, the progress of green campus development in China is summarized, including all the initiatives to conduct the energy and resource efficient campus, and the current status of upgrading the energy and resource efficient campus to the green campus; the problems occurred during the development are analyzed, and the possible approaches and the action plan are explored accordingly, to promote the green campus development. It is found from the analysis that the development of energy and resource efficient campus has been expanded in a large scale in China, mainly aiming at the energy efficient technology application and campus energy management, and all these initiatives are strongly promoted by the national government with policy support and financial funding. With these great endeavors, an upgrade from the energy and resource efficient campus to the green campus is on progress, which expands its scope to sustainable education and the initiative of low-carbon life on campus. However, many problems also occurred during the progress, such as the lack of a good top-level design among different national ministries and the collaborative innovation among different departments in the university, and the need of a practical propulsion mode and a long-term mechanism to guarantee green campus development. Hence, some suggestions are made in terms of the administrative management, propulsion approach, evaluation standard, and action plan.

1. Introduction

The higher education in China has achieved rapid growth. As shown in Fig. 1, by the end of 2011, there are a total of 2409 universities and colleges in China with 24.26 million students. The total floor area of campus buildings amounts to 780.76 million m^2, which is more than five times of that in 1998 (MoE, 2012). According to the statistics, annual total energy consumption in universities and colleges is nearly reaching 30 million tons of standard coal, and annual water consumption is nearly 4 million tons in China. The energy consumption per student and water consumption per student are four times and two times as large as that of Chinese residents respectively (National Bureau of Statistics of China, 2009; Yuan et al., 2013). Under the background of the adjustment of social economy structure and the transformation of industrial production structure, the ratio of energy use in Chinese universities and colleges to the total national energy use becomes larger and larger, which attracts great social attention. Meanwhile, as the base of knowledge transformation, sci-tech talents cultivation and technical innovation, it is very significant to promote campus ecological civilization and to endow the universities a great duty of leading the sustainable development of society.

In 2007 the first demonstration project of energy and resource efficient campus was set up in Tongji University. This initiative drives a big batch of Chinese universities to build energy and resource efficient campus. The construction of the campus energy management system (CEMS) has become an important approach

* Corresponding author. Research Center of Green Building and New Energy, Tongji University, 1239 Siping Road, Shanghai 200092, China. Tel.: +86 021 65980778; fax: +86 021 65981002.
E-mail addresses: hw_tan@tongji.edu.cn, hn_csq@126.com (H. Tan).

0959-6526/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jclepro.2013.10.019

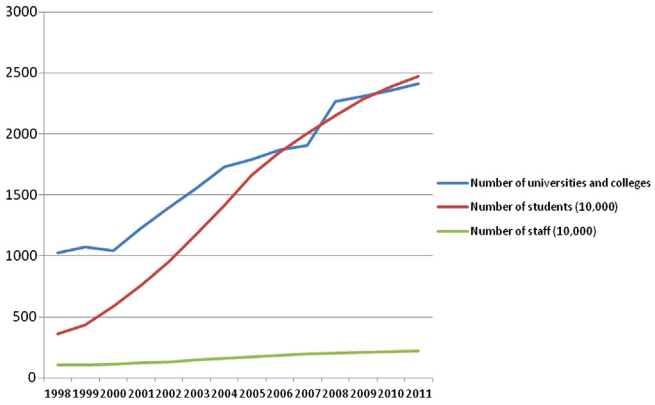

Fig. 1. Developments of Chinese universities 1998–2011.

associated with eco-tech application and green education for energy and resource efficient campus. So far, more than 200 universities and colleges have been funded to build the CEMS, jointly boosted by the Ministry of Housing and Urban–Rural Development, the Ministry of Education and the Ministry of Finance. Among them, more than 30 universities and colleges have established their CEMS, and successfully passed the acceptance tests. Great achievements and experiences were gained from this initiative, and hence it was highly regarded by the United Nations Environment Programme, the related international alliances for sustainable developments, and the domestic and foreign higher education institutions.

The work of green campus in foreign countries more focuses on spreading the idea, publicity and education. As early as in 1972, the conception of green school was put forward in the Stockholm Conference on the Human Environment, asking for the attention on the education of environment protection (Xu, 2010). In 1990, over 300 university administrators in over 40 countries have signed the Talloires Declaration, a 10-point action plan for incorporating sustainability and environmental literacy in teaching, research, operations and outreach at colleges and universities (ULSF, 2013; Habib and Ismaila, 2008). In 1992, the UN conference on Environment and Development was held in Rio, Brazil. In 1994, UNESCO put forward that the concept of sustainable development should be integrated in the education, and conducted the EPD (Education for Environment population and Sustainable Development) project, which aimed to accelerate the environment improvement, population quality uplift and social sustainable development, by the environment education, population education and sustainability education of adolescent and the whole society (Xu, 2010). The increasing importance of declarations and conferences, for fostering transformative sustainable development is evidenced by more and more university leaders who ratified their commitments to work to enhance sustainable development education and research (Calder and Clugston, 2003; Cole and Wright, 2005). For instance, some American universities launched the Non-Profit Organization of C2E2 (The Campus Consortium for Environmental Excellence) for the purpose of sustainability-oriented education and publicity (Xu, 2010). The Australian National University also set its sustainability targets and implementation strategies to guide environmental management to 2015 and beyond, including the initiatives in environment protection, education and student engagement and so on (Australian National University, 2009). Compared with the foreign mode in which the foreign universities spontaneously pay more focuses on the idea spread, publicity and education, and have relatively weak enforcement of energy efficient technology application projects, the green campus development in China begun with the eco-technology demonstration and facility energy management with strong enforcement from the government, and this leads to deal with concrete matters related to energy and resource efficient campus, and then more fields are gradually covered, and this finally promotes the upgrading from the energy and resource efficient campus to green campus. It is a step-by-step progress from the concept to the practice and from several demonstrations to the popularization on the whole campus, and may involve more people and work processes on campus. It takes the campus energy management as the start point, and put the green concept and technology into the construction and operation of campus facilities. An effective CEMS with energy and resource consumption monitoring tool for all buildings on campus has been set up and given a powerful support for energy audit and energy efficient retrofit. Complete institutions have been worked out to guarantee these initiatives. Finally green education, green research, and green campus culture are involved besides the energy and resource conservation.

In this paper, the progress and trend of green campus development in China were summarized, and aiming at the current status, especially the existing problems, some practical approaches on how to boost green campus development are put forward.

2. Progress of campus development in China

The green campus development can be tracked back to 1990s, and it takes nearly two decades from the beginning of green school advocacy, to the energy and resource efficient campus development, to the current green campus development, as shown in Fig. 2. In 1996, the State Environmental Protection Administration, the Ministry of Education and the Propaganda Department of CPC Central Committee jointly promulgated the “Action Outline of National Environmental Publicity and Education (1996–2010)”, and put forward to the activities that till 2000, the country gradually carried out the creation of ‘green schools’, which mainly aimed at primary and secondary schools.

Beginning at the unprecedented merger of institutions and enrollment in 1990s, the campus infrastructure construction presented the climax in China. During the formation of “Education for Sustainable Development” concept in the international, many problems were occurred during the campus construction in China, like the campus unconventional scale expansion, oversized land use, commercialized landscape and luxury building, which got serious attention from the society.

The Ministry of Education issued the “Circular of the Ministry of Education on carrying out the spirit of the State Council to focus on the near future key work of building a conservation-oriented society” (Education [2005] No. 19). Later in 2006, the Ministry of Education issued a notice on the construction of resource efficient schools (Education [2006] No. 3).

In 21st century, the universities in China have started their active exploration within the context of the international community highly concerned environmental issues. The concept of green university emerged in the theory of university operation based on the concept of sustainable development, and all the work in universities should be organized and implemented from the perspective of long-term sustainability of the university. The scope and definition of green university was put forward at this stage, but the concept is too broad and macro. Moreover, there was lack of detailed target on how to realize the green university, and the concrete measures were not figured out as well. Therefore, it mostly remained in the advocacy level of green concept.

China has strengthened the building energy conservation work since 2006, which was a critical period of the “Eleventh Five-Year plan” of national economy development. In 2007, Tongji

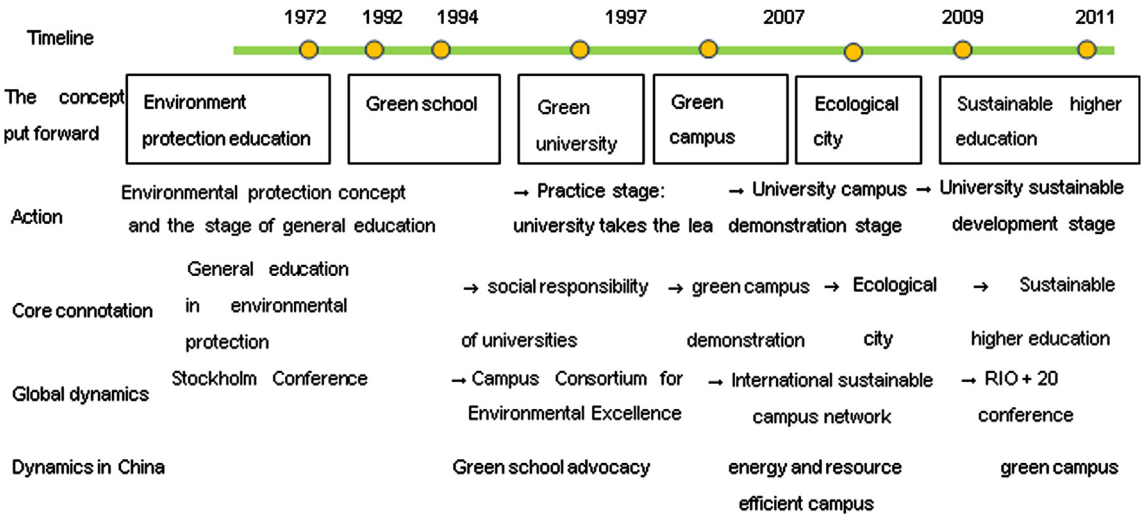

Fig. 2. The evolution from energy and resource efficient campus to green campus in China.

University successfully applied the funding for the first demonstration project of energy and resource efficient campus in China. Different from the previous stage with only green concept and no executive approach, Tongji University conducted the energy and resource saving demonstrations, and established the CEMS for the overall management of the energy use on campus. The green ecological concepts and technologies have been put into the practice of campus construction and operation, and the energy and resource saving target has been realized, making Tongji University a successful model of campus-saving. Hence, the Tongji model has won the first prize of Science and Technology Progress Award issued by the Ministry of Education in 2008 (Tan et al., 2012).

In 2008, organized by the Ministry of Education and the Ministry of Housing and Urban–Rural Development, Tongji University led the composition of The Construction and Management Guidelines of Energy and Resource Efficient Campus in Colleges and Universities, united with Tsinghua University, Tianjin University, Zhejiang University, Chongqing University, and Shandong Jianzhu University. The guideline makes it clear that the action core of energy and resource efficient campus development is to save land, energy, water and material, and environmental protection. Its important approach is to establish a CEMS (Ministry of Housing and Urban–Rural Development, and Ministry of Education, 2008). In 2009, a series of guidelines were worked out for the construction, and management of the CEMS, the energy consumption statistics, audit and evaluation on campus, as shown in Table 1. The establishment of energy and resource efficient campus demonstration can be guided by these guidelines, so as to indeed promote campus energy conservation. Until then, energy and resource efficient campus development in colleges and universities had a specific positioning, a clear roadmap and a concrete approach, which provided a good guidance for building energy and resource efficient campus in colleges and universities.

In January 2008, Chinese Ministry of Education held the Sustainable Campus Forum in Tongji University; the participants of 32 universities directly subordinate to the Ministry of Education jointly issued the "Tongji Declaration" on China's sustainable development campus. This Declaration conveys a broader concept of sustainable development in universities and covers various aspects of sustainability in higher education such as sustainable curricula, research and development for education students and society on sustainable societal decision-making, and encouraging students' to engage in activities related to sustainability (Yuan et al., 2013).

From 2009 to 2012, with the joint guidance and special funds support of the Ministry of Housing and Urban–Rural Development, the Ministry of Education and the Ministry of Finance, the demonstration construction of the CEMS has gotten popularization

Table 1
National policies on building resource efficient campus in Chinese universities.

Publish year	Document name	Reference number
2005	"Circular of the Ministry of Education on carrying out the spirit of the State Council and focusing on building a conservation-oriented society"	[2005] No. 19
2006	"Circular on building energy and resource efficient schools	[2006] No. 3
2007	"Circular of the Ministry of Education on carrying out actions on energy conservation and carbon reduction in schools"	[2007] No. 19
2008	"The Construction and Management Guidelines of Energy and Resource Efficient Campus in Colleges and Universities (trial implementation)"	[2008] No. 89
2008	"Opinions on promoting energy and resource efficient campus development, and further strengthen energy conservation and water conservation in colleges and universities"	[2008] No. 90
2009	"Notice on printing and distributing the "campus construction guidelines of campus energy management system in colleges and universities" and relevant management measures" "Technical guidelines of campus energy management system construction in colleges and universities" "Energy efficiency operation and management guidelines of campus energy management system" "The guidelines of energy consumption statistics, audit and publicity on campus" "The efficient operation and management guidelines of campus facilities" "Energy efficiency indices & evaluation guidelines of energy and resource efficient campus in colleges and universities"	[2009] No. 1163

in Chinese universities and colleges. By the end of 2012, more than 200 demonstrations of colleges and universities have successfully gotten the special fund for the demonstration construction of the CEMS, and among them more than 30 colleges and universities have successively finished demonstration construction and passed the approval from the Ministry of Housing, and Urban–Rural Development. The establishment of the CEMS is just the first stage of energy and resource efficient campus development. On this base, energy auditing and quota can be made via the energy consumption data monitored by the CEMS in the 2nd stage, and energy efficient retrofit of existing buildings can be made accordingly. Currently, the work in the 1st stage was basically completed, and the work in the 2nd stage is still in progress, while in the 3rd stage, the work scope is expected to be expanded and deepened, so as to upgrade to green campus development. Fig. 3 shows the development stages of energy and resource efficient campus.

In March 2011, under the guidance of the Ministry of Housing and Urban–Rural Development and the Ministry of Education, "China Green University Network (CGUN)" was established. Currently there are totally 18 member units. There are two prerequisites for the membership enrollment: firstly, only the universities which have demonstration construction of The CEMS passed the national acceptance test can become the members; secondly, the university broads must agree with the enrollment of their universities with the signature of the president or competent vice president on the application form. The main missions of CGUN are: (1) to reinforce inter-university cooperation and exchange in the field of green campus development; (2) to provide support for the national policy making to advance green campus development; (3) to promote collaborative research, innovation, and popularization of energy conservation and carbon reduction technology in campus facilities; (4) to train senior talents in the field of green campus and sustainability; (5) to provide practical demonstration bases for the green education, green research and the cultivation of green campus culture; (6) to lead the development of Green Universities in China. CGUN is administrated by the presidium which consisted of the representatives of the member universities, i.e. presidents or vice presidents. The chairman of CGUN is elected from the presidium members and rotates every two years. As the decision-making body, the presidium oversees the strategic planning of CGUN such as constitution amendment and approval of new members. The secretariat is responsible for day-to-day activities. Currently, the chairman of CGUN is the vice president of Tongji University, and secretariat is permanently set in Tongji University. In addition, 11 professional committees were established to work on various aspects of green university, namely the profession committee of green campus policy research, the profession committee of green campus planning and architectural design, the profession committee of intelligent buildings, the profession committee of energy conservation for space heating, the profession committee of water resource utilization, the profession committee of new and renewable energy deployment, the profession committee of energy efficiency management, the profession committee of energy monitoring and regulation, the profession committee of energy efficiency metrics, the profession committee of sustainable education, and the profession committee of waste treatment and environment monitoring. CGUN is expending its scale, and more than 50 universities are expected to join CGUN by 2015, including the universities from the mainland, Taiwan China, Hong Kong China, Macau China and other foreign universities in the Asia-Pacific region (CGUN, 2011).

In 2012, the International Sustainable Campus Network (ISCN) awarded Tongji University 'Excellence in Campus Award', which was the first time for the universities of the Asia-Pacific region to get this honor.

In June 2012, the United Nations conference on Sustainable Development (Rio+20) was held in Rio DE Janeiro in Brazil. With the joint efforts of the CGUN and other related networks in Australia, the United States and the Europe, a side event for sustainable higher education was successfully organized, and the Rio+20 Declaration was issued. The Rio+20 Declaration covers five key aspects of higher education sustainability, i.e. teaching sustainable development concepts, encouraging research on sustainable development issues, greening of campuses, supporting sustainability efforts and fostering and engaging in international collaboration (UNCSD, 2012). As of 2 July 2012, five Chinese universities have signed the Rio+20 Declaration. These five universities are: Beijing Normal University, Central South University of Forestry and Technology, Renmin University of China, Tongji University and Tsinghua University.

In the early stage of campus energy conservation work, although the concepts of green schools, eco-campus, Green University have already been put forward at home and abroad, it has been difficult to be implemented due to the lack of specific approaches and concrete measures, so most of them just remained in the eco-awareness education level. In China, the demonstration

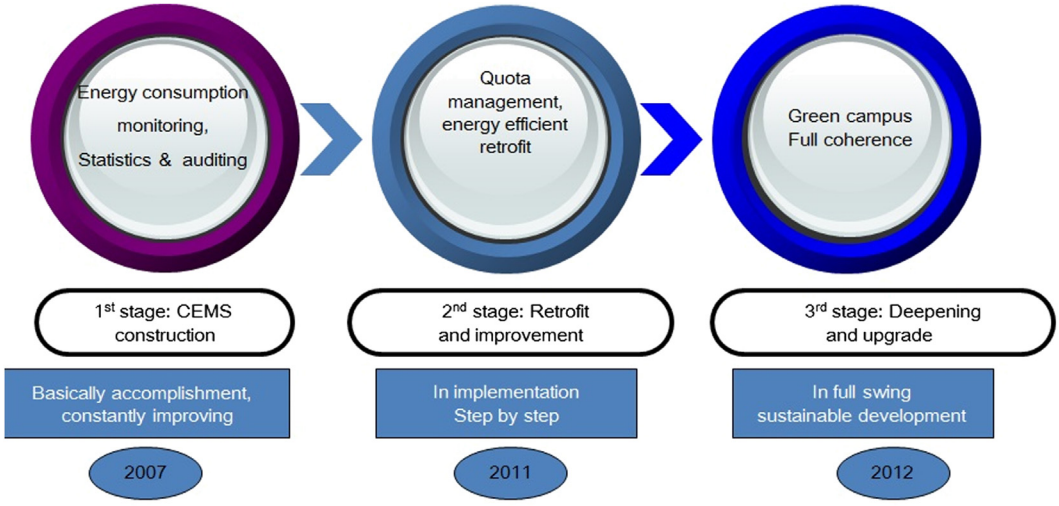

Fig. 3. Development stages of energy and resource efficient campus.

project of energy and resource efficient campus which began from 2007 was the important turning point, which was from the virtual to the real, and extended from the shallow to the deep, really opening up the pathway that leaded to the development of green campus in China.

3. Promotion from energy and resource efficient campus to green campus

In order to make the energy and resource efficient campus development smoothly, a strong university-level leadership and coordination organization need to be established. A good top-level design is also important for the construction and operation of energy and resource efficient campus. Energy conservation is the core of the energy and resource efficient campus, and hence to make the construction and operation of campus infrastructure energy efficient is the key point of the energy and resource efficient campus. In order to realize this, the demonstrations of energy-saving technology in campus buildings and facilities are expected to be applied, and the CEMS must be constructed for the energy statistics, energy auditing, energy efficient retrofit, and energy-saving operation.

The CEMS can monitor the real time energy use of campus buildings, and show the real time data of energy use to the users numerically and visually. To a further step, it makes the management of campus facilities with large quantities automatically and intelligently. On this base, the energy-saving benefit can be measured and evaluated, so as to provide a strong support for the energy use quota regulation.

More importantly, by the monitoring and data publicity of campus energy use and environmental quality, this CEMS also becomes a platform to popularize green concept, promote the education of green technology and science, and to carry out scientific research related to energy conservation and environment protection for the students and staff who live and work on campus.

This CEMS provides an important foundation for the upgrading from energy efficient campus to green campus. Fig. 4 shows the framework of this system. Fig. 5 shows the connotation of energy and resource efficient campus, green campus and sustainable university, and the inherent relationship among them. The content is expanded and the connotation is also promoted when energy and resource efficient campus is upgraded to green campus. The core value of green campus is green ecological, and campus software and hardware construction should be done simultaneously, with the green ideas put into practice in different areas of education, research and campus culture, etc. The practice of energy conservation and emission reduction of campus facilities is taken to support green concept. Its ultimate goal is to point to sustainable development of the university. The university should use sustainable development as the core concept to run the school, and finally form such kind of university with the guiding and capacity of sustainable development, and leading the sustainable development of the society.

Energy efficient campus focuses on campus capital construction and operation, and is mainly associated with the developments of school infrastructure, logistics and other departments. Its specific objective is the campus energy-saving and water-saving.

Then, the establishment of green campus is to expand the working scope of energy and resource efficient campus to more school administrative departments, such as the office of teaching affairs, the division of research, and the developments of assets and equipment, and the work fields are also extended from the energy and resource conservation of energy and resource efficient campus to green campus planning and construction, energy-saving retrofit of existing buildings, the buildings of healthy environment, low-carbon campus life advocacy and other aspects.

Green campus development will find a new approach to lay equal emphasis on the soft power of green environment protection and the fixed low-carbon target, and will be full life cycle assessment-oriented. The hardware construction of green campus should focuses on infrastructure construction and operation, while the software construction covers the cultivation and spread of green humanity, and talent cultivation in sustainability. The

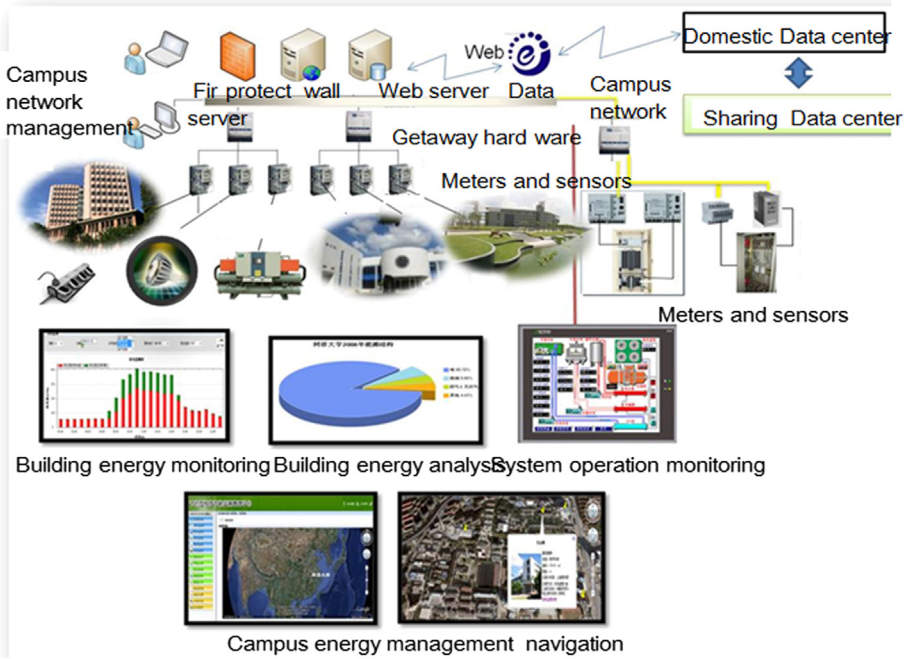

Fig. 4. Campus energy management system (the structure and platform function).

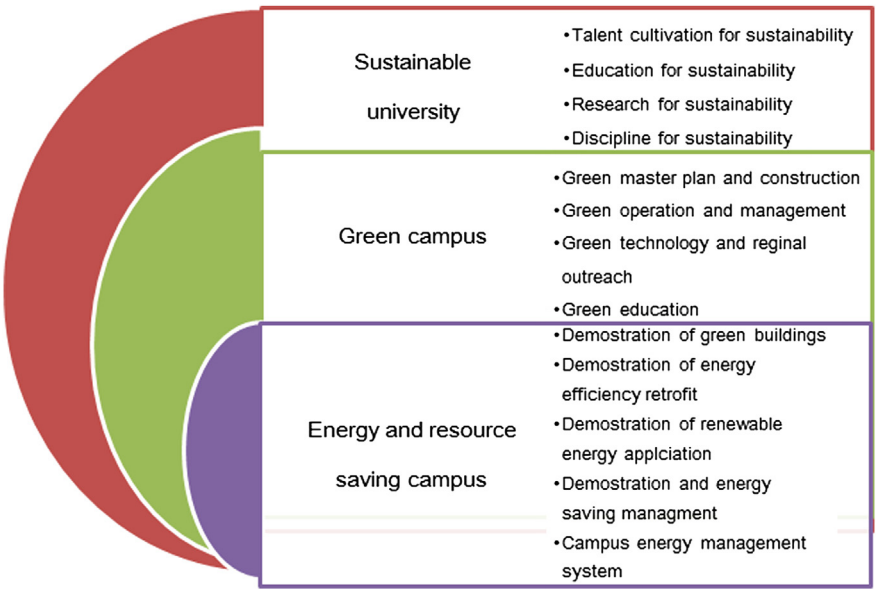

Fig. 5. The connotation of energy and resource efficient campus, green campus and sustainable university.

ultimate goal is to form a core value by integrating concept of sustainable development into university education, to make the University's contribution to the sustainable development of society.

4. Critical thinking of green campus development in China

The advancement of green campus development in China cannot remain at the concept of publicity, and neither remains at several demonstrations of green buildings. It is necessary to undertake and carry forward the achievements of energy and resource efficient campus, but also set up a long-term goal of sustainable development of university. Therefore, it should further improve the top-level design, have a mechanism innovation and collaborative innovation, and establish a scientific evaluation system with long-term mechanism.

4.1. Top-level design of organizational management and collaborative innovation among administrative developments

From the perspective of hardware, green campus development focuses on energy conservation and carbon reduction in the operation of campus infrastructure and facilities, while from the perspective of software, it covers the cultivation and spread of green humanity, and talent cultivation in sustainability.

Therefore, from the national level, the competent administrative departments of this work involve Ministry of Education, Ministry of Housing and Urban–Rural Development, Ministry of Environmental Protection. A scientific top-level design and intense overall planning and management are necessary. Up to now, the main impetus of the demonstration projects of China energy and resource efficient campus is from the Ministry of Housing and Urban–Rural Development, and the Ministry of Education, as well as with the support of Ministry of Finance. However, the development from energy and resource efficient campus to green campus need integrate green teaching, scientific research, and even the operation of the university. Therefore, it needs the coordination and participation of more related departments and it also put forward a higher requirement for the top-level designing. Meanwhile, the linkage mechanism between central and local government need establish as well.

From the university level, the development of green campus involves the coordination and innovation of every department throughout each link of campus operation and management, and requires the joint participation of teachers and students as well. Therefore, the top-level designing in university level is also necessary and it involves establishment and improvement of organizational structure, the setting goals and the institutions (Lozano, 2006; Comm and Mathaisel, 2005). "Construction and Management Guidelines of Energy and Resource Efficient Campus in Colleges and Universities" issued in 2008 covers most of aforementioned principles and contents, but it's necessary to define their responding duties and rights of every functional department in the green campus development. This part of work basically belongs to the increment of work for each development, and hence it's necessary to establish the system construction and incentive mechanism to advance the development of green campus, and insure the completeness of organization construction and the necessary support of financial resources, material resources and human resources, otherwise it's just a flash in the pan.

4.2. The propulsion mode of green campus development

By reviewing the achievements of energy and resource efficient campus development, and comparing the experience of green campus development home and aboard, it is found that to advance the work of green campus needs the combination of "virtual" and "real"(the combination of theory and practice), the integration of "point" and "sphere"(the combination of demonstration projects and popularization), the supplement of "soft" and "hard"(natural science and social science), the linkage of "inside" and "outside"(the integration and complementation of resources), the combination of government and university (the advocacy of government and the policy support, and the spontaneous conduction by universities themselves). Besides, a scientific evaluation system is also needed to assess the application of technology, the process control and management, regular inspection and the dynamic supervision.

High level of ideas, hotness of education campaigns and sensitivity of students are always the characteristics of the foreign green campus development. However, it lacks the strong policy support from the government and the effective enforcement of the demonstrative projects. The common mode of foreign green campus development is the bottom–up. In contrast, in the recent years, developmental feature in China is a government-driven, top–down model with the great attention from the central government, high concentration of planning and coordination, strong implementation capacity of demonstrative projects, and high speed of development. Actually, these two models should not be biased. Only through the integration can it play the great effect and ensure the sustainable development. We need to strengthen the connection of each other and work together by taking the advantages – supports and assistants from the government, and observing our disadvantages of the consciousness of indifference and the lagging of the conscious action.

At the same time, we should set up the sustainable development pattern: ideas first, with the support of demonstration and practice, and the establishment of long-term effective mechanism. Practice demonstrates that the inane concept is just a flash in the pan, while we need demonstration practice to support and extend the ideas, and we also should pay more attention in establishing the innovation of management system, strengthening the capability building, and forming the long-term mechanism. The green campus development in China is confronting a lot of problems and challenges in the current system and capacity building. Green campus development has already put into effect, but most administrative organizations belong to loose coordinating organizations. Only by combining the theory and practice, making the popularization based on the demonstration, and guaranteed by the good mechanism can stimulate the long-term development of green campus.

4.3. The evaluation system of green campus

It is the important guarantee for green campus development in China to establish an evaluation system and methodology of green campus. As green campus differs from green buildings, the evaluation system, standards and methods of green buildings can't be imitated completely.

The evaluation of green buildings focuses on individual buildings. Even if now it extends to the blocks, communities and schools, it is only suitable for building or architectural stocks. As aforementioned, green campus is a community referring to certain geographical range and spatial scale, complex buildings and facilities, diverse function needs of teaching, scientific research and living, the diverse participants as teaching staff and students, we need to establish a multiplex, qualitative and quantified evaluation system and we need to break through the fixed thinking of current technical standards and to keep pace with the times.

First of all, the evaluation of green campus needs to establish a scientific evaluation index system. Fig. 6 gives the involved scope of

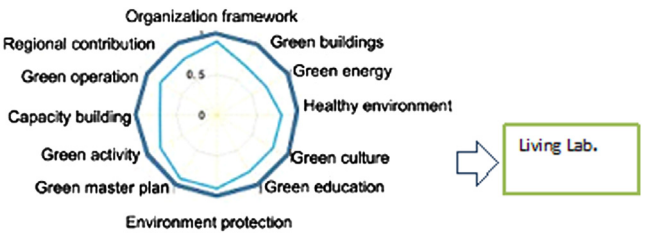

Fig. 6. Involved scope of green campus evaluation.

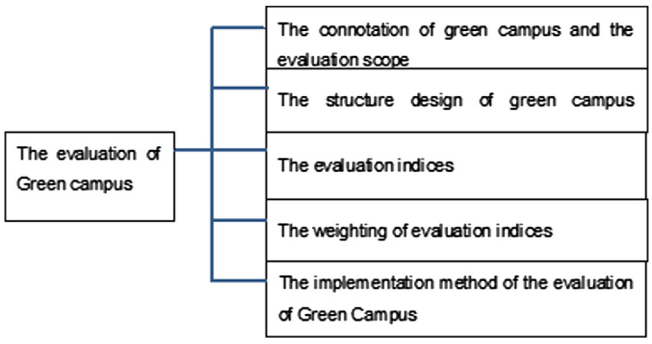

Fig. 7. The framework of green campus evaluation methodology.

green campus evaluation, and Fig. 7 lists the overall framework of the evaluation methodology of green campus. According to the principle of scientificity, objectivity, applicability, coordination and promptness, the evaluation indices should be set out based on the deep research of green campus, and the weighting of evaluation indices should also be fixed by expert scoring method or other related statistical method. Besides, the evaluation system of green campus is not only the technical standard, but also the management method. We can refer to the idea of ISO Environment Management Standard, and strengthen the process control and form the regular censorship.

4.4. Action plan for green campus development in China

Green campus development will be expanded in a much larger scale in the coming years in China. With the policy support of national ministries, including the Ministry of Housing and Urban–Rural Development, Ministry of Education and Ministry of Finance, more and more universities will begin to construct the CEMS for the campus energy use management. On the base of the CEMS construction, a few energy and resource demonstration universities have been conducting the energy efficient retrofit for campus buildings and facilities right now, with the financial support of 4 million RMB for each university from the Ministry of Finance, and this action is expected to be popularized in more and more Chinese universities in the next step. Besides that, the evaluation of demonstration unit of green campus is projected to be carried out in Chinese universities, which is currently being fermented by the national government. The evaluation standard will be promulgated and the related procedures will be set out as well, and the green campus evolution will lead and also promote the development of green campus in China.

5. Conclusions

The demonstration project of energy and resource efficient campus, which began in 2007, initiated the exploration of sustainable development path among Chinese universities. Green concept has been the main stream on campus. On this basis, carrying out the development of green campus in a deep-going way is not only the needs of building a sustainable-oriented society, but also the mission of universities.

Over the years, although some encouraging fruits have been born in the process of energy and resource efficient campus development, many problems and challenges occurred waiting for the solution. The concept of sustainable development needs to be set up in order to carry forward this work. The establishment of the CEMS is an important measure and plays a positive role in the energy and resource efficient campus development, but to ensure the system of sustainable development still has a long way to go.

Lacking of institutional guarantee and capacity building began to appear in some universities, which needs to carry out the corresponding structural reform, establish institutional guarantee and provide professional technical support as soon as possible. Green campus development is the expansion and extension of energy and resource efficient campus development, and it needs to base on the thorough summarization of the experience and lessons of energy and resource efficient campus development, and formulate and perfect the guidelines and evaluation standards scientifically, to ensure its sustainable development.

The CGUN is pondering over and exploring how to base on sustainable development, to initiate a unified key value concept in colleges and universities, to guide the university campus to develop from energy and resource efficient campus to green campus in depth and breadth, making university the main stream of leading the sustainable development of the society.

Acknowledgements

The work is supported by the 12th Five-Year National Science and Technology Support Plan (2012BAJ15B03), the Science and Technology Plan Project of the Ministry of Housing and Urban-Rural Development in China (2013-R1-17), and National Natural Science Foundation of China (70972072).

References

Calder, W., Clugston, R.M., 2003. International efforts to promote higher education for sustainable development. Plan. High. Educ. 31, 30–44.

China Green University Network, 2011. Introduction to China Green University Network. http://www.cgun.org/en/content.aspx?info_lb=107&flag=107 (accessed 23.06.12.).

Cole, L., Wright, T., 2005. Assessing sustainability on Canadian University campuses: the development of a campus sustainability assessment framework. In: Filho, W.L. (Ed.), Handbook of Sustainability Research. Peter Lang Pub Inc., Frankfurt am Main, pp. 705–725.

Comm, C.L., Mathaisel, D.F.X., 2005. A case study in applying lean sustainability concepts to universities. Int. J. Sustain. High. Educ. 6 (2), 134–146.

Habib, M. Alshuwaikhat, Ismaila, Abubakar, 2008. An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. J. Clean. Prod. 16, 1777–1785.

Lozano, R., 2006. Incorporation and institutionalization of SD into universities: breaking through barriers to change. J. Clean. Prod. 14 (9–11), 787–796.

Ministry of Education, 2012. Bulletin of National Education Statistics 2011. http://www.gov.cn/gzdt/2012-08/30/content_2213875.htm (accessed 30.08.12.).

Ministry of Housing and Urban–Rural Development, and Ministry of Education, 2008. Construction and Management Guidelines of Energy and Resource Efficient Campus in Colleges and Universities ([2008]89). http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/200805/t20080519_168885.html (accessed 13.05.08.).

National Bureau of Statistics of China, 2009. China Statistical Yearbook 2008. China Statistics Press, Beijing.

The Australian National University, 2009. The Australian National University Environmental Management Plan Implementation Strategies 2009 to 2015. http://sustainability.anu.edu.au/about-anugreen/environmental-management-plan (accessed 08.04.09.).

Tan, H.W., Chen, S.Q., Zhang, N., et al., 2012. Annual Report of Green Campus Development in China. China Green University Network. http://www.cgun.org/down.aspx?info_lb=120&flag=120 (accessed 16.04.13.).

ULSF, 2013. The Talloires Declaration. http://www.ulsf.org/pdf/TD.pdf (accessed 31.01.13.).

UNCSD, 2012. Higher Education Sustainability Initiative for Riot20. http://www.uncsd2012.org/index.php?page¼view&nr¼341&type¼12&menu¼435 (accessed 23.06.12.).

Xu, Y.L., 2010. Energy Efficiency Management of Campus Buildings in Hot Summer and Cold Winter Zone. Thesis for Master Degree. Tongji University, China.

Yuan, X.L., Zuo, J., Huisingh, D., 2013. Green Universities in China – what matters? J. Clean. Prod. 61, 36–45.