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## The theory and framework of integration design of building consumption efficiency based on BIM

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### Abstract

Presently in China many challenges are existing in building energy efficiency, such as the detachment between building design and its energy efficiency, the complicated working process on building efficiency design, the difficulty for architects to get efficient facilities, all of which cause problems to the design of building energy efficiency.

This paper bases its design principle on the concept of synergy between building design and energy-saving technology and integrates the energy-saving design experiences of tradition buildings with BIM's powerful ability on information processing and quantitative analysis according to which an energy-saving method and process that builds its foundation on BIM technology and makes the information exchanging among multi subjects and phases and plan adoption possible is put forward in this paper. The goal of this study is to promote the application of BIM technology and provides ideas and ways for the congregated design of building energy efficiency.

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### 1. Introduction

The related research at home and abroad in the past thirty years on the topic of building energy efficiency has covered the fields of energy-saving technology, ecological technology, evaluation system,

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use of renewable energy, use of renewable materials, building environment simulation (such as heat, light, wind and sound), building energy consumption simulation (BECS), economical analysis, etc. However, it is gradually found that solutions for the problems of building energy saving through certain theory or some energy-saving design or one single energy-saving technology can not achieve the ideal result. For example, Garrett analyzed the case of failed passive solar energy and pointed out that the failure was caused by the lack of economic efficiency and design defects<sup>[1]</sup>. Therefore, the integrated design method based on system theory and cybernetics<sup>[2]</sup> and the energy-saving design method standardized on energy assessment of buildings' life cycle<sup>[3]</sup> have attracted the attention of the academia.

Even though the importance of energy-saving design has been widely recognized, there still exist insurmountable obstacles in the ideas and technologies for traditional energy saving design. This paper plans to start from the view of BIM technology and explore a new energy efficiency design concept and method which will make use of the advantages of BIM technology on integrated information and provides an effective platform for a comprehensive building energy efficiency design.

## 2. Related research

### 2.1. Reality and problems in building energy-saving design

The problems faced by Chinese traditional building energy-saving work are as follows:

- On the concept of energy saving design there exists the trend that puts more emphasis on technology than design. For many of the existing energy conservation demonstration projects, energy saving is always identified as visible and tangible high technology but buildings' design itself is put behind, such as building's shape and the envelop structure.
- There exists the problem of incomprehensive building energy consumption (BEC) assessment on energy saving evaluation which puts more attention on the equipments' operating energy consumption, while ignoring the indirect energy consumption of the material energy consumption (MEC) in the construction process and energy spent on the production and transportation of all the equipments. Some foreign scholars' research on energy consumption in the buildings' life cycle shows that for some energy-saving buildings, the percentage of the energy consumption of building materials among buildings whole life cycle energy consumption can reach up to 40%<sup>[4]</sup>.
- There exists the detachment between energy-saving technology and building design on energy-saving design method. For traditional design method, building energy efficiency is categorized as one of the technological subjects, and the design concept that lacks of synergy effect among different jobs makes the energy saving technology distant from architecture design.
- There exists the problem of "solitary information island" on the application of design technology. Building is a complicated system in which all factors interacted with each other and it is hard to define which building design is better. Nowadays in China the commonly used energy consumption software is based on the two dimension CAD design platform, which stops the information sharing between building design and calculation of energy consumption so that the phenomenon of "solitary information island" appears.

In front of the above mentioned issues, the study on two fields worth attention. One is about BEC. With reference to the theory of product life cycle, focus is begun to put on building life cycle, the core meaning of which refers to the comprehensive evaluation on BEC in the building's life cycle that constitutes three phases, namely building production, its usage and abandonment. Chinese professor Jiang Yi proposes general energy consumption (GEC) theory about building which says BEC should include building's operating energy consumption (OEC), material energy consumption (MEC) and its abandonment energy consumption (AEC).

The second is about building integrated design(BID) that also begins to attract attention in related international fields. Integrated design requires cooperation among multi subjects and its goal is to meet the comfort standard with low energy consumption. Passive design and active design is integrated in the design process and through reasonable moderation on the relations among the building, its envelop design, the heating and air conditioner facilities energy efficiency is improved. International Energy Agency has successively funded a series of research projects on building integrated design and the related technology, namely “Annex 23: Solar Low Energy Buildings and Integrated Design Process” , “Annex 32: Integral Building Envelope Performance Assessment”<sup>[5]</sup>. These projects conducted a preliminary study on integrated design process and the related technologies and provided an original frame.

## 2.2. Research on BIM

BIM is the abbreviation of “Building Information Modeling” that is the digitalized expression for building facilities’ physical and functional features. As shared building information resource, BIM is not only used in building design, but also in structure design, equipment management, statistics of project quantity, cost calculation, property management, etc. BIM can also play its role in the whole construction industry and provides solid foundation for all decisions of building life cycle.

Since its appearance in mid-80s, BIM technology has existed for twenty years in which period the international academia has been doing active exploration on CAD information modeling and gets a consensus and this technology has got fast development at abroad in recent years. According to statistics, 48% of Architectural Design Firms in America use BIM technology<sup>[6]</sup>.The studies on energy saving design includes: using BIM modeling to do energy consumption analysis at early-stage building design<sup>[7]</sup>, the application of BIM technology in passive design and the assessment of energy consumption<sup>[8]</sup>, energy saving design method based on building information modeling<sup>[9]</sup>. The study shows that using BIM technology could effectively and apparently balance project cost and energy efficiency.

## 3. Research frame

### 3.1. Theoretical research

In order to implement the integrated design on building energy saving that is based on BIM technology firstly we need to understand the concept of integrated design and the workflow of BIM. Integrated design considers the building as a whole system and optimizes the whole process from the point of building’s life cycle. It has following features:

- Its design process considers the traditional building and technological integration as its study focus;
- It is based on actual situation rather than formality which means BIM uses flexible or suitable technologies to acquire the dynamic interactive information between building and environment;
- It is based on multi subjects and can meet the needs of designers with various academic backgrounds that require synchronous communication under different conditions;
- It is because of the above features that integrated design gets that the energy saving design based on this concept can make the best out of the whole design.

On the other hand, BIM’s advantages on data management provide an excellent operation platform for integrated design. The object-oriented method used by BIM technology includes the buildings’ comprehensive information such as the three-dimensional geometric information, all of which information can be reused and calculated and could significantly contribute to the consistency of project information in different phases. BIM technology can provide quantitative assessment in every phase of building

design. All these features make the BIM technology stand out in building energy design especially under complicated environment.

### 3.2. Work frame

Energy saving design includes architecture design, passive and active energy saving technology all of which data will be used by staff in different departments, such as architects, energy-saving engineers, structural engineers and HVAC engineers, etc. In order to carry out energy saving design, large quantity of data operation work needs to be done, such as calculation work on environment simulation and energy consumption simulation. The theory of building life cycle states that BEC includes not only the energy consumption that appears in the stage of building construction but also in the phase of building abandonment. All the data calculation work can be done by BIM data management platform so that all the above mentioned obstacles can be avoided. Figure 1 indicates the function theory.

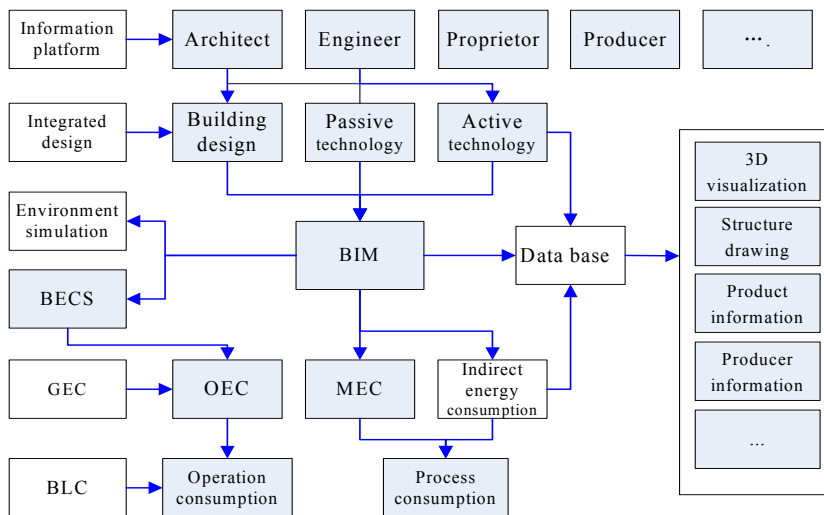


Figure 1 Data management of BEC based on BIM

BIM provides a platform based on which building energy saving design can be structured. The building scheme based on this technology can make the work of energy consumption simulation and assessment be done at design's early stage, which will completely change the traditional detachment problem between project design and energy efficiency design and can effectively ensure the realization of full life cycle assessment of building and general BEC. Figure 2 shows the work flow.

### 4. Conclusion

The integrated design method based on system theory and cybernetics and the energy efficiency design concept standardized on building life cycle's energy consumption assessment shows advanced energy efficiency concept. However, for China's present building energy saving design work, this concept hasn't been fully put into application. BIM technology can effectively overcome the traditional technology's disadvantages and becomes an effective means to realize the integrated design of building energy efficiency and the energy consumption assessment of building life cycle. With this background, this study illustrates the problems existing in the China's traditional energy efficiency design and displays the function theory of the energy saving design based on BIM technology as well as proposes the

corresponding working frame. Yet this study is basically a theoretical assumption and more field work still needs to be done. The study enriches the contents of both theory and method on building energy efficiency and has significant influence on BIM technology's application and promotion.

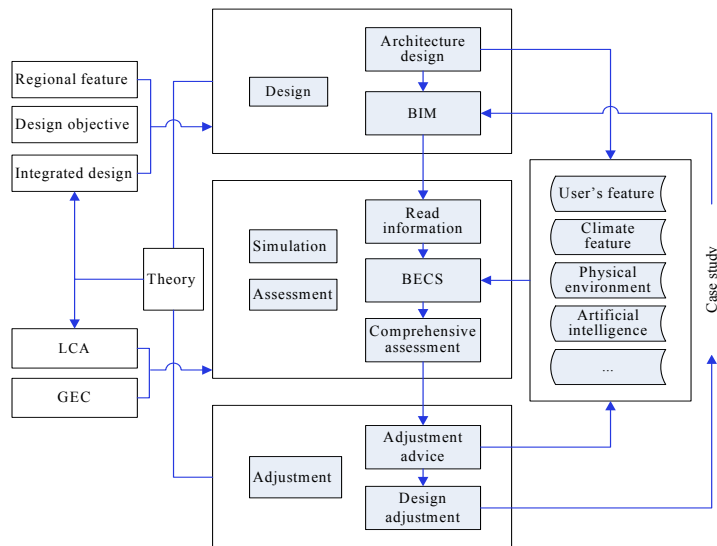


Figure 2 Framework of building energy efficiency design based on BIM

## References

- [1] Garrett, Vicki; Koontz, Tomas. Climate change, energy, and economics: Why isn't every building passive solar? *Proceedings of the ASME International Solar Energy Conference - Solar Engineering* ;2006
- [2] Cornick, S.M.; Maref, W.; Lacasse, M.A. The Virtual lab: a research complement to the integrated design process. *10th Conference on Building Science and Technology Proceedings*, 2005; v2 p.63-75
- [3] Teasdale-St-Hilaire. The role of building engineering on integrated design and building sustainability, *Proceedings of the 3rd International Building Physics Conference - Research in Building Physics and Building Engineering*, 2006; p. 509-516
- [4] Nalanie Mithraratne; Brenda Vale. Life cycle analysis model for New Zealand houses. *Building and Environment*.2004, 39(4); p.483-492.
- [5] IEA Task 23. Integrated Design Process : a Guideline for Sustainable and Solar-Optimised Building Design[OL]. [http://www.iea-shc.org/publications/downloads/IDPGuide\\_internal.pdf](http://www.iea-shc.org/publications/downloads/IDPGuide_internal.pdf)
- [6] Arno Schlueter; Frank Thesseling. Building Information Model Based Energy/exergy Performance Assessment In Early Design Stages. *Automation in Construction* , 2009,18(2) ;p. 153-163
- [7] Stumpf, Annette; Kim, Hyunjoo; Jenicek, Elisabeth. Early design energy analysis using bims (building information models). *Building a Sustainable Future - Proceedings of the 2009 Construction Research Congress*, 2009;p.426-436
- [8] Charalambides, Jason. Improving energy efficiency in building through automated computer design process. *Building a Sustainable Future - Proceedings of the 2009 Construction Research Congress*, 2009;p. 628-635,
- [9] Yoon, Seung-Hyun; Park, Nam-Hee; Choi, Jin-Won. A BIM-based design method for energy-efficient building. *NCM 2009 - 5th International Joint Conference on INC, IMS, and IDC*, 2009;p.376-381,