Research on Building Energy Consumption Based on BIM

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Abstract. In recent years, the issue of energy consumption in the building sector has been studied. The application of BIM has increasingly in ACE (Architecture, Engineering, and Construction) industry. Based on the characteristics of BIM, the paper studies the benefit of building energy consumption analysis. BIM information can be imported and converted in energy consumption simulation software. The BIM technology provides different data interface, which could dock with a variety of energy analysis software. BIM can be transformed into building energy model. Based on the analysis of BIM information importing process and parameter setting function of energy consumption simulation process in BIM-based energy consumption simulation software, the BIM model imports the energy consumption simulation software for building energy consumption simulation analysis, it is concluded that the specific problems of the energy saving design. The paper put forward that combined BIM technology with energy analysis during building design, which will help implement green building sustainable design.

1. Introduction

With the rapid development of China’s construction, the contradiction between the high energy consumption situation and sustainable development strategy of the construction industry is increasingly obvious. The building energy consumption in China increased year by year and the proportion in the total energy consumption was growing. The energy consumption of buildings accounts for a total energy consumption of about 30%, with the constant development of economy, building energy consumption in China will be all increasing constantly. BIM (building information modelling) has developed into an effective solution that can improve many aspects of construction industry. BIM technology is able to realize the continuous updating and collaborative management of building information data in life cycle by using uniform data standards. In the design phase, energy efficiency measures are combined with better system integration. Energy consumption analysis based on BIM is widely used at home and abroad. BIM has a good and useful source of information data for building energy analysis, the data will be more efficient and more reusable. By using BIM, building energy consumption analysis and evaluation can be carried out in the life-cycle of the building[1]. The geometry and material information needed to build an energy input file was automatically collected from a BIM file and parsed for energy simulation[2].
The application of BIM in building energy simulations has greatly improved the energy analysis process and this approach has gained momentum[3].

2. Building energy consumption analysis

Building energy consumption analysis is an important part for building energy efficiency design. The energy consumption analysis of buildings is to analyze the influence of the change of the properties of the building on the annual energy consumption of buildings by means of simulation calculation, so as to provide a scientific basis for architects to improve design.

2.1. Energy simulation

Designing, building and managing an energy efficient building can be a complex and daunting task. Building energy simulation offers a valuable tool for engineers and architects to evaluate building energy consumption at the early stage of building design and optimize the building model performance. This information can help designers make better informed decisions that cost-effectively improve the performance and reduce the environmental impact of buildings. It can also be used to study the impact of building modification on building energy use. Alternative designs or materials can immediately be evaluated to see how much they affect the annual energy consumption and this can help designers select energy efficient designs.

2.2. Traditional building energy consumption analysis

There are many problems in traditional energy consumption analysis, such as information is difficult to obtain, energy consumption analysis of complicated process, the results of the analysis is not accurate. It is apparent that traditional building energy consumption analysis methods for data analysis are insufficient. One is calculate building thermal/cold load by using static algorithm, this method ignores the building heat transfer delay and attenuation effects, which will result in large deviation of calculated load compared with actual load. The other is making energy analysis by manually inputting the relevant data of building to dynamic simulation software. This method often requires lots of manual input, and the operation of these softwares usually requires complex professional knowledge about energy analysis and computer science. The input procedure is extremely complicated, and nonprofessionals cannot conduct operation analysis simulation on the vast professional data if they have not had vocational training[4].

3. Energy analysis of building based on BIM

3.1. Energy simulation analysis based on BIM

Building Information Modeling (BIM) is being increasingly accepted by ACE industry as an innovative method for integrating many information data related to a building. There are various building energy modeling tools capable of importing these BIM files to perform energy simulation. BIM has greatly improved the efficiency and accuracy of building energy efficiency design, to minimize the duplication of work, and making the project information sharing significantly proved. The use of simulation to predict building energy performance has been shown to have significant benefits in terms of reducing energy consumption and greenhouse gas emissions.

3.2. BIM energy simulation analysis tool

BIM system software manufacturers are also incorporating Building Performance Analysis (BPA) tools within the scope of their software development and integration efforts, and the tools support both whole building energy analysis and more targeted design studies (like daylighting and solar radiation analysis) to help optimize building performance[5]. Examples include Green Building Studio[6], Bently’s Hevacomp series[7] and IES VE[8], Graphisoft EcoDesigner STAR[9], and PKPM-Energy[10], HY-EP[11] and GBSWARE BESI[12]. In Table1. summarizes and compares software tools, supported file formats, visualization items, and simulation engine items.
Table 1. Energy consumption simulation analysis software based on BIM currently used

| Software tools          | Supported file formats | Visualization items                                                                 | Simulation engine |
|-------------------------|------------------------|--------------------------------------------------------------------------------------|-------------------|
| Green Building Studio[6]| gbXML、IFC             | Dynamic whole building energy simulation, provide energy use, water use, and carbon  | DOE-2             |
|                         |                        | emission results, estimate building energy use and operating costs                   |                   |
| Bentley Hevacomp[7]     | gbXML、DXF、DGN、DWG、IFC、SKP、3DS、CIS2 | Energy analysis, three-dimensional visualization of external shading, indoor sunlit areas | Energy Plus       |
| IES VE[8]               | gbXML、Revit、DXF      | Whole-building energy simulation, solar shading, daylight simulation, climate analysis | Apache            |
| Graphisoft EcoDesigner STAR[9] | gbXML、PHPP、iSBEM、VIP-Energy | Building energy load analysis, meteorological data analysis, energy optimization settings | VIPCore           |
| PKPM-Energy[10]         | Revit                  | Energy analysis                                                                      | DOE-2             |
| HY-EP[11]               | gbXML                  | Energy simulation analysis                                                            | Energy Plus       |
| GBSWARE BESI[12]        | gbXML、CAD             | Calculation of energy consumption simulation analysis                                 |                   |

3.3. Benefits of BIM in building energy analysis

BIM is endowed with capabilities that can be used to virtually perform energy analysis and accurately predict building energy use. The virtual 3D building model can be created with BIM application software as an electronic database containing all of the building's information. By importing the model into the energy analysis tool, a large amount of information in the model can be identified and analyzed automatically, and the energy efficiency analysis results can be obtained quickly and conveniently. Energy analysis tool with a BIM model helps to expedite the energy analysis process, provide more detailed and accurate results as well as deliver energy-efficient buildings design. Building energy simulation is one of the techniques to minimize the demand of energy consumption. BIM software Revit was used to model build, as well as analyze the energy consumption and energy saving design[13].

3.4. Process of building energy consumption based on BIM

The virtual 3D model created with BIM is an electronic database containing all of the building's information. With BIM information importing process and parameter setting function of energy consumption simulation process, the BIM information on typical elements of the building can be imported and converted into building energy model. We can automatically identify and analyze the model's great amount of information so as to quickly and easily get the energy efficiency analysis results by importing 3D building model into energy analysis software. Architects can analyze the building's energy performance of the design conveniently at any time and optimize a plan to achieve an energy-efficient, sustainable building by multiple choices of alternative designs. The workflows of energy consumption analysis based on BIM is shown in Figure 1.
3.5. Example
Firstly, it use Revit2018 software to establish the building information model, which can manage buildings’ information such as buildings’ space geometry information, space function information, materials and equipment information and so on, as shown in Figure 2. Secondly, revit will automatically create an Energy Analytical Model (EAM) from the building elements in the model (walls, windows, ceilings, roof, etc.), and pass that information to Green Building Studio for energy simulation. After data conversion, the BIM model will be exported to special format file(gbXML) for building energy consumption analysis. Finally, gbXML files can be uploaded directly to the Green Building Studio website and GBS can embellish them as needed to be fully-populated energy analysis models that can be simulated with the DOE2-based simulation engine in GBS. Green Building Studio® (GBS) is a software for analyzing the whole building energy simulation engine, GBS is a web-based analysis service that allows you to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process. GBS will help extend your ability to design high performance buildings and the best energy efficient, sustainable design was recommended to architects for future projects[14]. This means that an architect, engineer, or analyst can quickly generate reasonable energy simulation results from creating building model by the site of climate, terrain features, building type and the location, as shown in Figure 4, 5, 6.

Energy Analysis Model (EAM) are used in whole building energy simulations, and gbXML file is a common format for representing these models. Making a valid Energy Analysis Model (EAM) for whole building energy analysis is a vitally important step, as shown in Figure 3.
Figure 3. Energy Analysis Model of Library

Figure 4. Total Energy and Electricity Monthly Data of Library

Figure 5. Annual Electric End Use of Library

Figure 6. Annual Fuel End Use of Library

4. Conclusion
BIM has developed into a powerful solution that can improve the issue of energy consumption in the construction industry. Based on BIM building energy simulation analysis is one of technique to minimize the demand of energy consumption. The results show BIM software was used to model building, as well as analyze the energy consumption and energy saving. Based on the analysis of BIM information importing process and parameter setting function of energy consumption simulation process in BIM-based energy consumption simulation software, the BIM model imports the energy consumption simulation software for building energy consumption simulation analysis, it is concluded that the specific problems of the energy saving design and energy consumption analysis in the building life cycle.
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