Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(3):467-471

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Comparison of software for building energy simulation

Ying Han*, Xiao Liu and Li Chang

College of Civil and Architectural Engineering, Hebei United University, China

---

ABSTRACT

A wide variety of building energy simulation software have been developed, enhanced and used throughout the building energy researches. The paper introduces major building energy simulation software, such as DOE-2, Energy plus and so on. It also provides the comparison of the features and capabilities of several major building energy simulation programs. All of these building energy simulation software have their own advantages and disadvantages. The choice of building energy simulation software should follow the design phrase and the simulation characteristics.

Keywords: building energy, simulation, comparison, software, characteristics

---

INTRODUCTION

Last 60 years, nearly hundreds of energy simulation programs developed and used throughout the building energy community all around the world. Because of the increasing requirement of building energy simulation, several countries developed building energy simulation software. For example, DOE-2 developed by American Lawrence Berkeley National Laboratory, ESP-r developed by British Energy System Research Unit, CLIM2000 developed by France and DEST developed by Chinese Tsinghua University.

These building energy simulation software can be divided to two types. One type is based on heating, ventilation and air-conditioning (HVAC) systems. The software usually used to simulate components of air-conditioning systems, such as TRNSYS、SPARK and HVACSIM etc. The object of these types of software is to simulate dynamic characteristics of system consist of a variety of modules and response of different control methods. In addition, they have simple room model and complex system model, therefore, they possess flexibility of combination of different system form. The other type is based on buildings, mainly used for dynamic simulation of buildings and systems, such as DOE-2、EnergyPlus and ESP-r so on. The object of these software is to simulate dynamic heat characteristics of long periods (usually at hourly time step). They are applicable for building envelop dynamic heat transfer and the whole years' operation energy consumption.

2. Major software

Major building energy simulation software are DOE-2, eQUEST, EnergyPlus, ESP-r, DeST, Transys and so on in China. Their characteristics were shown as follows.

2.1. DOE-2

DOE-2 software was developed by James J. Hirsch & Associates (JJH) in collaboration with Lawrence Berkeley National Laboratory (LBNL), with LBNL DOE-2 work performed mostly under funding from the United States Department of Energy (USDOE) in 1970s.

DOE-2 is a building energy analysis program that can predict the energy use and cost for all types of buildings. As shown in Fig.1, It has one subprogram for translation of input building description Languages (BDL) Processor, and

four simulation subprograms LOADS,SYSTEMS,PLANT and ECON. LOADS, SYSTEMS and PLANT are executed in sequence, with the output of LOADS becoming the input of SYSTEMS. The output then becomes the input to ECONOMICS. Each of the simulation subprograms also produces printed reports of the results of its calculations. The BDL processor reads input data and calculates response factors for the transient heat flow in walls and weighting factors for the thermal response of building spaces.

Researchers and experts uses a description of the building layout, constructions, operating schedules, conditioning systems (lighting, HVAC, etc.) and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills [1].

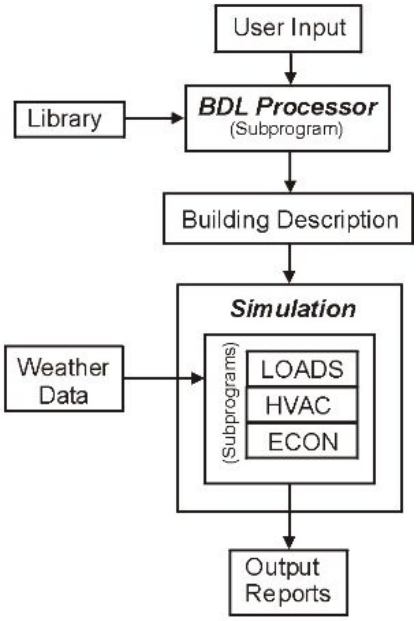

Fig. 1. DOE-2 flow chart

2.2. Energy Plus

EnergyPlus is a whole building energy simulation program that engineers, architects, and researchers use to model energy. Modeling the performance of a building with EnergyPlus enables building professionals to optimize the building design to use less energy. It is developed by Lawrence Berkeley National Laboratory, University of Illinois, U.S. Army Construction Engineering Research Laboratory and Oklahoma State University [2].

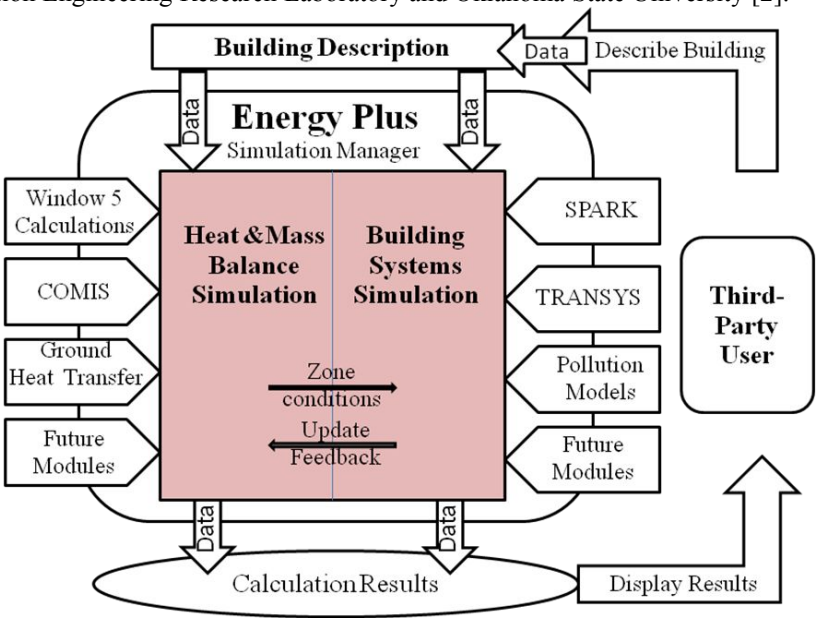

Fig. 2. Energy plus flow chart

It builds on the most popular features and capabilities of BLAST and DOE-2, but beyond them. It includes innovative simulation capabilities including time steps of less than an hour, modular systems simulation modules that are integrated with a heat balance-based zone simulation and input and output data structures tailored to facilitate third party interface development. Other planned simulation capabilities include solar thermal, multi-zone airflow, and electric power simulation including photovoltaic systems and fuel cells. The flow chart and modules are shown in Fig.2 and Fig.3.

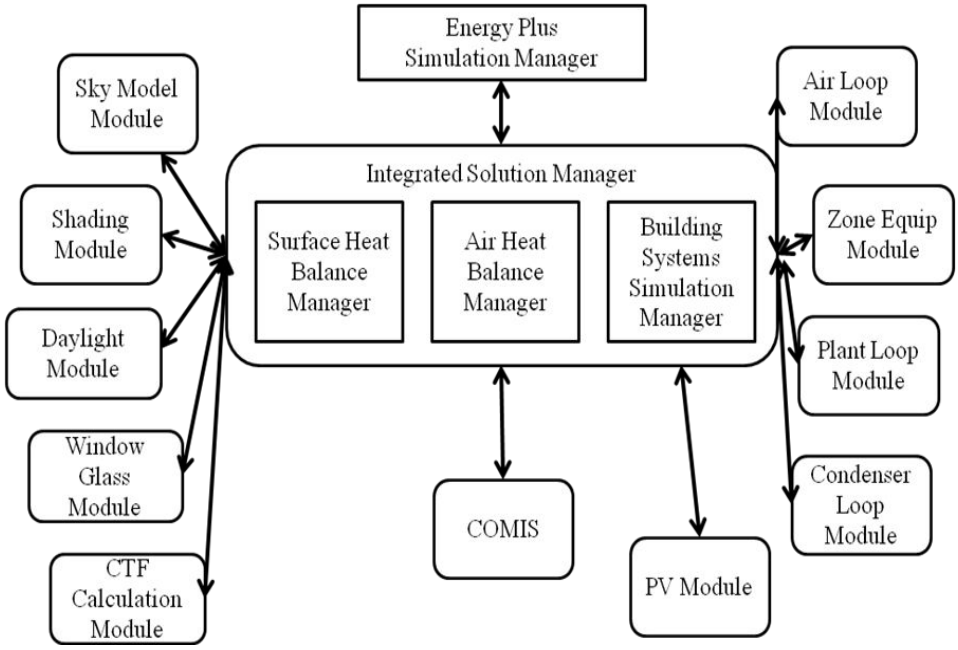

Fig. 3. Energy plus modules

2.3. eQUEST

eQUEST is a complete interactive Windows implementation of the DOE-2 program with added wizards and graphic displays to aid in the use of DOE-2. It is accomplished by combining a building creation wizard, an energy efficiency measure (EEM) wizard, and graphical reporting with a simulation "engine" derived from the latest version of DOE-2. It is a sophisticated, yet easy to use building energy use analysis tool which provides professional-level results with an affordable level of effort. It involves following a series of steps that help the user describe the features of building design that would impact energy use. The operation interface is shown in Fig.4.

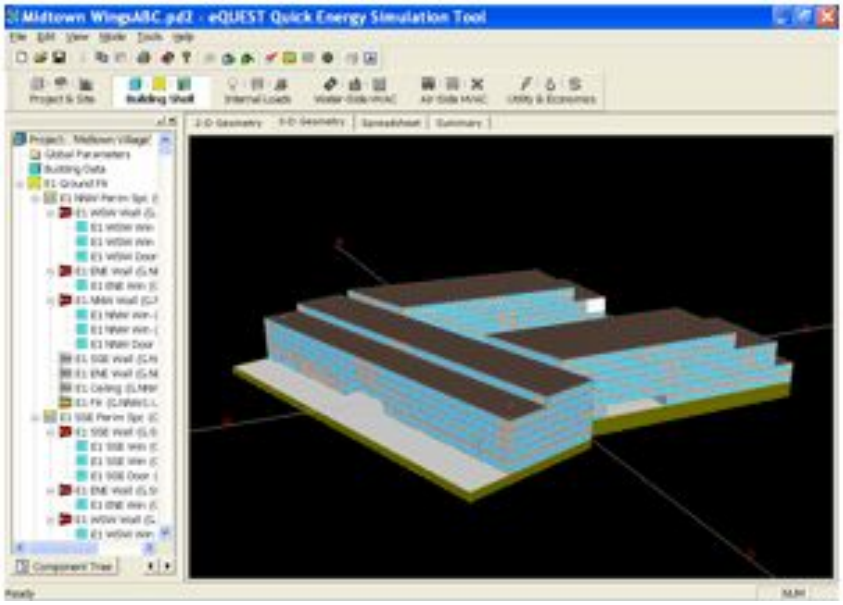

Fig. 4. eQUEST operation interface

2.4. ESP-r

ESP-r was developed in 1970s by Energy System Research Unit in University of Strathclyde.

Energy Simulation Program for Research (ESP-r). It is an integrated energy modelling tool for the simulation of the thermal, visual and acoustic performance of buildings and the energy use and gaseous emissions associated with associated environmental control systems.

ESP-r has a world-wide development community and its distribution is managed under Subversion source code control. The system is made available at no cost under an Open Source licence. However, it is operated under UNIX operation system.

2.5. TRNSYS

TRNSYS is a transient systems simulation program with a modular structure. It recognizes a system description language in which the user specifies the components that constitute the system and the manner in which they are connected. The TRNSYS library includes many of the components commonly found in thermal and electrical energy systems, as well as component routines to handle input of weather data or other time-dependent forcing functions and output of simulation results. The modular nature of TRNSYS gives the program tremendous flexibility, and facilitates the addition to the program of mathematical models not included in the standard TRNSYS library. TRNSYS is well suited to detailed analyses of any system whose behavior is dependent on the passage of time. TRNSYS has become reference software for researchers and engineers around the world. Main applications include: solar systems (solar thermal and photovoltaic systems), low energy buildings and HVAC systems, renewable energy systems, cogeneration, fuel cells.

Whereas, If the short time steps are selected, the amount of calculation will increase and cause slow operation even computer crash. In addition, it is difficult to deal with real building models.

2.6. DeST

Designer's Simulation Toolkits (DeST) is developed by Tsinghua University. It is a tool for detailed analysis of building thermal processes and HVAC system performance. It can provide hourly building thermal performance, energy consumption and ratio of loads satisfied by the HVAC systems, and economic cost results base on the user description. Based on these results, designers can choose the best option at different stages in the design process.

There are five versions in the DeST software, i.e. DeST-h for residential buildings, DeST-c for commercial buildings, DeST-e for building evaluation, DeST-r for building ratings and DeST-s for solar buildings[3]. It has been widely used in China for various prestige large structures. This is because it not only has Chinese operation interface but also the AutoCAD interface. Therefore, it is easy for users to build the building in AutoCAD.

3. Comparison of Software

It is introduced the major building energy software in China above. According to the two types of division, it is compared DOE-2, Energy plus, ESP-r, eQUET and DeST below. As shown in Table1, Table2 and Table 3.

Table 1. Comparison of basic characteristics

	DOE-2	eQUEST	EnergyPlus	ESP-r	DeST
Import CAD drawing		√	√	√	
Changeable time step		√	√	√	
Export CAD drawing			√	√	
Output report		√	√	√	√

Table 2. Comparison of calculation capability

	DOE-2	eQUEST	EnergyPlus	ESP-r	DeST
Room heat balance calculation		√	√	√	√
Humidity calculation		√	√		√
Heat comfort calculation			√	√	
Nature ventilation calculation		√	√	√	√
Sunlight analysis	√	√	√	√	
Renewable energy calculation		√	√	√	

Table 3. Comparison of compatibility

	DOE-2	eQUEST	EnergyPlus	ESP-r	DeST
Water cycle calculation		√	√		√
Wind cycle calculation					
Greenhouse gas	√	√	√	√	
Connection with other software			√	√	√

CONCLUSION

The paper just introduces some of the building energy simulation software and gives simple comparison of the major software. From the introduction of the "mature" software, there was not a quite common language to describe the tools could do. It requires more additional work to resolve the problems. It is known that early design decisions may not require a detailed simulation program to deal with the massing. So users should consider adopting a suite of tools to support the needs of their practice.

REFERENCES

[1]Li Ji, Zou Yu, Wei Zheng. *Building Science*. **2010**, 26(2):25-28.
[2]Crawley D B, Lawrie L K, W inkeimann F C, et al. *Energy and Buildings*. **2001**, 33(4):319-331.
[3]Yan Da, Xie Xiaona, Song Fangting and Jiang Yi. *Heating, Ventilation and Air-conditioning*. **2004**, 34(7):48-56.