

## **BUILDING SIMULATION 2007: The Study on the Simple HVAC Interface of EnergyPlus in Chinese**

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### **ABSTRACT**

EnergyPlus is a new building energy simulation program supported by American DOE. Based on the most popular features and capabilities of BLAST and DOE-2, it is primarily a simulation engine without good interface. There's an original interface called IDF editor supported by EnergyPlus, and users must input the simulation data with complex lists while using it. The boring inputting and all-English interface make the energy simulation so inconvenience that keep lots of new users away from the software although it has a precise and steady engine, especially the local users in China. A simple interface of EnergyPlus in Chinese has been developed with the advantages of the structure and object-orientation of Microsoft Visual Basic 6.0. The interface of beta version can basically input the data required by EnergyPlus and then run the simulation with the engine of EnergyPlus. The new interface has a lot of merits, including straightforwardness and practicality, reliability and universality, full-function and easy to use, which will make more Chinese acquaint with EnergyPlus, but it is still not perfect for some bugs and incomplete HVAC system.

### **KEYWORDS**

EnergyPlus, energy consumption analysis, Chinese, user interface, object-orientated program

### **INTRODUCTION**

With the development of Interactive performance of different software, such as FORTRAN, Visual C/C++, Visual Basic, Visual FoxPro, it is common to develop some applications (such as in architectural energy consumption analysis and HVAC related fields) using multiple languages in order to maximize each language's own advantage. Aiming at the unfriendly American energy consumption analysis software, EnergyPlus interface, we developed a Chinese user interface which uses EnergyPlus as its calculation. This software is based

on multiple languages, and object-oriented program designing.

### **ENERGYPLUS—A PROGRAM USED FOR ENERGY CONSUMPTION CALCULATION**

#### **Background**

EnergyPlus is a new but very effective program, one based on the most popular features and capabilities of BLAST (building loads analysis and system thermodynamics) and DOE-2 (department of energy). It is sponsored by the US Department of Energy, developed by Lawrence Berkeley National Laboratory together with other research centers. The latest version of EnergyPlus is 1.4.0 and was released in October 2006.

EnergyPlus not only inherits the good characteristic and function of BLAST and DOE-2, but also has a lot of new features in terms of calculation methods and program structure. Neither BLAST nor DOE-2 is able to correctly handle feedback from the HVAC system to the zone conditions. However, EnergyPlus calculate all loads first, and then simulate systems and plants. While EnergyPlus is the integration of all aspects of the simulation—loads, systems, and plants, that is, in EnergyPlus the simulation is coupled, allowing the designer to more accurately investigate the effect of under sizing fans and equipment and what impact that might have on the thermal comfort of occupants within the building.

From the testing edition to the first formal edition released in 2001, EnergyPlus has passed the comparing test for ASHRAE Standard 140P and BEPAC heat exchange test. The results have showed good consistency between EnergyPlus and other energy consumption simulation programs.

EnergyPlus is written with a new version of FORTRAN, whose structure and modularization make it easy to maintain, renovate and extend. But we should realize that the programmers of EnergyPlus have spent most of their time and energy into the cyber-code, so EnergyPlus does

not have a friendly user interface. The input and output data are displayed as ASCII text, which will be difficult for users. Though the 1.01 edition (2002) of EnergyPlus has an IDF editor, its English input system still confuses our Chinese users evidently.

Users can download the American version of EnergyPlus simulation software for free at <http://www.eere.energy.gov/buildings/energyplus/>.

EnergyPlus is not a user interface; instead, it is intended to be the simulation engine around which a third-party interface can be wrapped. Inputs and outputs are simple ASCII text that is decipherable but best left to a GUI (graphical user interface). This approach allows interface designers to do what they do best. (Now more than 10 graphic interfaces are under development)

DesignBuilder is one of user interfaces to the EnergyPlus dynamic thermal simulation engine, which is combining rapid building modeling and ease of use with state of the art dynamic energy simulation. Its graphic interface makes user easier to create a building model, but the lack of HVAC function cause to inconvenience in systematic simulation. So we need a friendly interface with complete function for HVAC researching.

**Operation and Execution Process of EnergyPlus**

Figure 1 gives the structure of input and output. the whole calculation process can be seen as a linear process containing the following steps:

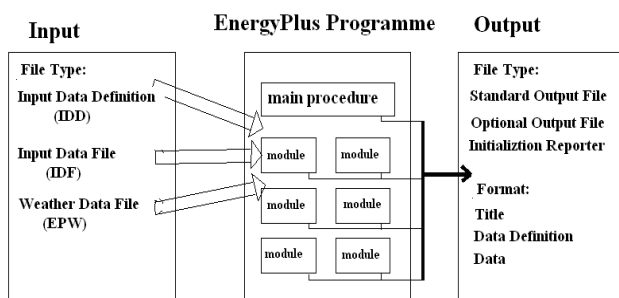


Figure 1 The structure of input and output

**Operation and Execution Process of EnergyPlus**

- Pre-process

Users can input some information of the buildings, such as building envelope, HVAC system, occupancy and so on, into the interface. Then the interface can save those parameters as an IDF document which can be used in the IDF editor. After determining which parameters to use,

users can also choose different output forms/reports according to their needs.

- Main execution area

The main procedure of EnergyPlus can load the IDF file through the input processor; then it can convert the input data according to input data dictionary. Every GetInput in the main procedure module can read correlative information in the loaded IDF file, and then the main procedure begins to calculate.

- Post-process

EnergyPlus can create output report according to users' will. The post-process program ReadVarsESO can convert the standard output files into a spreadsheet for creating graphs or other statistical operations.

THE PLAN OF DEVELOPING A CHINESE USER INTERFACE FOR ENERYGPLUS

**Programming Language to Choose**

After comparing some programming languages, such as FORTRAN, Visual FoxPro, Visual C/C++ and Visual Basic 6.0, the writer decided to use Visual Basic 6.0, which is easy to learn and handle for non-professionals, to develop a friendly Chinese user interface for EnergyPlus. Its main characteristics include API, DLL, DDE, OLE and ODBC, which can be compiled into some well-functioned application software system effectively and rapidly.

**Design of the Interface**

- The frame of a friendly Chinese user interface

A good input interface should be legible, practical, and easy to operate. But EnergyPlus is a stand-alone simulation program without a 'user friendly' graphical interface. EnergyPlus reads input and writes output as text files. There are so many input items to be dealt with and each item contains a lot of values. For example; we should define the roughness, thickness, conductivity, density and specific heat capacity when describing a construction material, which is complicated for users, especially for some new users. Based on these reasons, to develop a new interface, firstly we should predigest the whole items and make them easy to command for our Chinese users. By using of the idea of modularization and structure, the programmers have studied all items and put them into different groups/modules according to their functions. These new groups/modules can decrease

the cohesion among different items which make the graphical interface easy to understand and maneuver. These groups/modules are general situations of a building, such as construction material, geometrical characteristics of the building, occupancy of the building, HVAC system and control system.

- How to save input data

We can use EnergyPlus as a simulation engine. first we should know how to save data that users input in the graphic interface as an IDF document according to the input data dictionary. Inputs and outputs are saved as simple ASCII text that is decipherable, so people who are familiar with this program can read them from the screen.

- Load the calculating program and other processing programs of EnergyPlus, complete the whole operation

How to load the EnergyPlus' execution procedure through Visual Basic is the core of the Chinese user interface. EnergyPlus is a 32 characters application based on Windows™ operating system (Windows 95, Windows 98, Windows 2000, Windows NT, and Windows ME). Like other application, EnergyPlus has more than one executable program, and needs to load different input data during the controlling process. It would be hard to deal with those processes by manual operation and would be error-prone. So the programmer put all commands into one batch file orderly, such as RUNEP.BAT, and then set the paths of different input data as environmental variables of the batch file, for example, %epin% means the path of the input data (in.idf), %epwth% means the path of weather data (in.epw). During the Chinese user interface's main procedure, users only need to give the path of the input data to corresponding environmental variables, and then use the OLE (object linking and embedding) to connect the batch file. This way, it would spare a lot of keyboard input and improve the operating efficiency of the software.

After the above processes, users can load the calculation procedure of EnergyPlus and run various simulations more conveniently and effectively.

## INTRODUCTION AND INSTALLATION OF THE CHINESE USER INTERFACE

### **Installation of the Chinese User Interface**

Until now, EnergyPlus has released its latest version(1.4), and the new simulation engine in the Ver. 1.4 is also added in the interface, but the installation is easy and speedy. To make the Chinese user interface practicable and able to load the executable file and other dictionary files accurately, user should set the Chinese user interface at the same directory path as EnergyPlus.exe, Energy+.idd, Energy+.ini, RUNEP.BAT and so on.



Figure 2 Install of Chinese User Interface

User can double click the executable file to enter into the Chinese user interface, just as Figure 2 illustrates. For some common operation commands, such as “open”, “save”, “copy” and “paste”, the programmers have set corresponding keyboard shortcuts to make them more convenient to use.

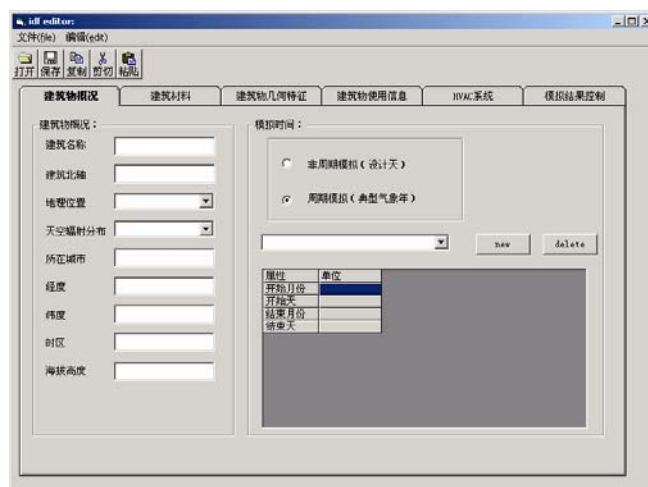


Figure 3 Input Interface of Chinese User Interface

### Data Input

Figure 4 and 5 demonstrate how to input data by using an IDF document named “Simulation 1”. For some single input items, such as building’s name, latitude or longitude, users can input directly into the TextBox; for some choice menus, users can choose by use of ComboBox, taking the choice menu geographical location as an example, users can choose among “City”, “Suburbs”, and “Country”; for some information with various but kin categories, users can click the “New” or “Delete” button to create or delete grids by using a combination of MSFlexGrid, CommandButton and ComboBox.

For common use of Energy Plus, user will not make full use of all EnergyPlus detail options, which will always get user confused because of the complicated items. Chinese user interface has simplified the data inputting during the simulation, by omitting unnecessary items or setting default value, which can reduce the time in looking up and inputting the object’s information while simulate the building perfectly.



Figure 4 Input Control Interface of Chinese User Interface

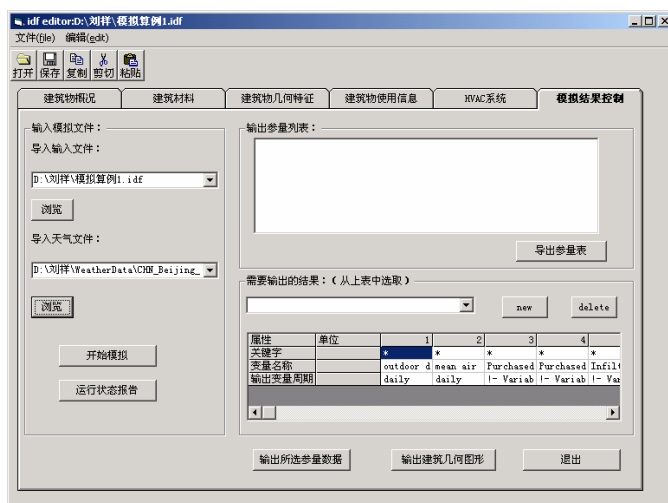


Figure 5 Output Interface of Chinese User Interface

### Energy Consumption Simulation

When we enter the control interface, we can select the IDF document that would be simulated later and demanded weather data, all these actions can be implemented by clicking the “Browse” button. See figure 5 for details.

After the users have done the selections and clicked the “Simulate” button, the Chinese user interface will load a batch file named runep.bat, then you can see a DOS command line and the calculating process till the whole simulation completes or terminates. Afterwards, a status message would show up if clicking the “Energy Run Status” button, which tells you the simulation is successful or aborted and some information about the error level and runtime. (Figure 6)



Figure 6 Energy Run Status

The eplusout.err file may contain three levels of errors (Warning, Severe, and Fatal) as well as the possibility of correction methods. These errors may be duplicated in other files (such as the standard output file). These errors are described more completely in the Output Details and Examples document. See Table1 for details.

Table 1 Error Level and Action

Error Level	Action
Warning	Take note
Severe	Should Fix
Fatal	Program will abort

**Output of the Simulation**

When the simulation is complete, the procedure can export results contained in the “standard” output files (eplusout.eso, eplusout.mtr) which are complicated and difficult for users to analyze. But these output files can be easily turned into commonly used spreadsheet programs where it can be further analyzed, graphed, etc.

For the Chinese user interface, users can choose the parameter needed by clicking the “parameter export list” button, run again, and will obtain data you need in the spreadsheet.

**Output of Drawing Files**

After successful simulating, the EnergyPlus can produce a DXF file in the IDF specification. Several software programs can render this file into something viewable, and the three-dimensional graphics of the building. They use different colors to depict envelop of building, roof, windows and door, so it is easy for users to detect and amend inaccurate input data of the building’ coordinates. After comparing among several graphical browsers, it is found that Quick View Plus and AutoDesk’s Volo View Express are rather effectual to read DXF files. Figure 7 gives an example of a room with ceiling and floor.

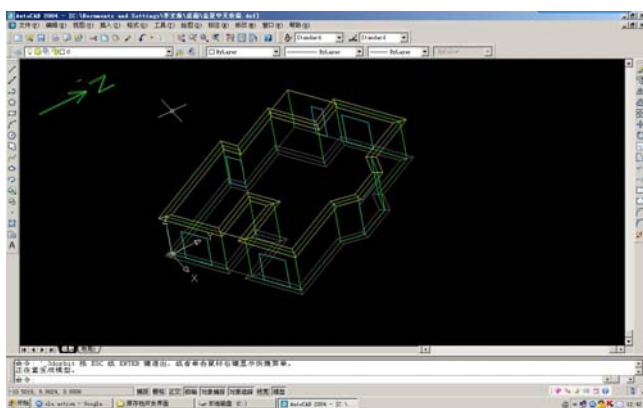


Fig.7 A DXF example created by EnergyPlus

Certainly, as functional software, the Chinese user interface also has some extra functions, such as caution reminder, saving reminder and so on.

**Further Development**

Until now, we have a Chinese EnergyPlus interface with adequate function to simulate building with HVAC system. But because of the basic conception of HVAC in EnergyPlus, HVAC data inputting is considered boring work which include complicated system construction and lots of data options. The Chinese user interface (ver. 1.4) also cannot solve the problem now, and need a further development in HVAC data inputting. During the development of the Chinese user interface, we have established a mature and steady platform for further researching and get useful experience in such as debugging of the program. Next step we will focus on the simplification of the HVAC data input in the Chinese user interface by HVAC option modularization (user can load the default modules matching the actual situation and change the setting as he wants) considering usability, user-friendliness, dependability and durability.

CONCLUSIONS

There are plenty of software for energy consumption calculation and analyses, but most of them do not have friendly user interface or Chinese language system that it is difficult for our Chinese users to operate. And some people have to create mathematic models according to their needs by using programming languages, which will result in a waste of manpower and material resources and need to be validated through a lot of experiments and practices. In addition, the created mathematic models have no universality. The writer has developed a friendly Chinese user interface for EnergyPlus by taking advantages of the structure and object-orientation of Visual Basic 6.0. The new interface has a lot of merits, including straightforwardness and practicality, reliability and universality, full-function and easy to use, which will make more Chinese acquaint with EnergyPlus. Also, it will help our energy consumption calculation and analyses catch up with the international standard. There might be some bugs in our Chinese user interface; users’ suggestions are welcome once you have found them.

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