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APPLICATION OF VARIOUS HVAC SIMULATION PROGRAMS AND VISUAL TOOLS TO COMMISSIONING

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ABSTRACT

Various existing HVAC system simulation programs and visualization tools are considered to be potentially powerful tools for commissioning. Although not originally developed as commissioning tools, these programs facilitate the confirmation/comparison of HVAC system function and performance and enable detailed analysis of parameters influencing HVAC system performance.

This paper investigates the functionality and ease of use of several such programs in support of the commissioning process. The investigation and assessment of simulation programs includes: Micro HASP, Micro ACSS, FACES, LCEM, HVACSIM+, TRNSYS, DOE-2, EnergyPlus and DeST and their visual tools.

KEYWORDS

Simulation program, visual tool, commissioning tool

INTRODUCTION

The commissioning (hereafter abbreviated as Cx) in each phase of building/HVAC system aims to meet fully the functionality and performance demanded by purchaser. The suitable simulation tools can be applied in verifying the function/performance of the HVAC system to make Cx executed adequately and effectively.

Many energy simulation programs of building/ HVAC system and visual tools (visual user I/O support interface) have been developed. The principal simulation programs are classified in Table 1 according to purpose of use and application phase. These programs, primarily used to calculate heat load of building or energy consumption of HVAC systems, also have useful applications in the comparison/confirmation of function and performance of HVAC system and for analysis of factor which influence the system performance by using calculation results of indoor environment and energy consumption. Although none of these programs were originally developed for Cx, it is hoped that they will become powerful tools for supporting Cx in the future.

In this paper, the application and convenience of several programs and their visual tools were considered. In addition, four kinds of Cx support tools were proposed which are suitable for program, planning, preliminary design, and operation phase respectively.

REVIEW OF MAIN PAST RESEARCH

In the report of the IEA ECBCS Annex 21(1998～1993), Environmental Performance of Buildings (L.Mansson,1993), it was clearly stated that a well maintained users manual and a high performance user interface were two necessary components to verify the reliability and application of 17 extant simulation tools and to expand the use of simulation in design phase according to a standard verification process.

In the report of the IEA ECBCS Annex 30(1995～ 1998), Bringing Simulation to Application (Peter,1998), a detailed examination of the usability of simulation tools for all phases of building/HVAC system was performed, considering management and succession of simulation information, and benefit and convenience of user interfaces etc. However, the scope of this work did not extend to the application of the simulation tools for Cx support.

In Japan, from 2002-2004, the Cx Tool Development Subcommittee of the SHASE Commissioning Committee 2002 ～ 2004 (SHASE,2004), primarily considered the application of simulation programs as Cx tools. The work included a comparison of function/ performance of main bodies of five programs using simulation results: HASP/ACLD/ACSS (SHASE, 1985), DOE-2(James, 2001), EnergyPlus (Anonymity), DeST (Jiang, 2004), HVACSIM$^+$(J) (SHASE,2003a). Since that time, the application and convenience of some programs (i.e., ASSIST (Systech Environment Lab, 2005) and DesignBuilder (Anonymity A)) were improved greatly with the development of visual tools. Then, in this survey study conducted in the Cx Tool Subcommittee of the Commissioning Committee in SHASE (lead by Harunori Yoshida) in Japan(2005～2007), through reviewing the manual of several programs and their visual tools and using them in practice, application and convenience of them as Cx support tool were considered.

ROLE OF SIMULATION IN Cx

From the program phase to the building/HVAC system operation, various tools are needed to confirm and evaluate the function/performance of the entire building/HVAC system, its subsystems and components. This section presents the difference between general simulation use and Cx support simulation for the planning/design phase of a building and for the program/planning phase through the operation phase for HVAC systems. It lists important general tasks that impact the commissioning process and the role of simulation. A summary of this discussion is listed in Table 2.

In planning and design phase of the building, the designer should calculate PAL (Perimeter Annual Load Factor) and BEE (Building Environment Efficiency) by using BECS (IBEC, 1994) and CASBEE (Ikaga, 2005) and prepare an energy savings report and an environmental load assessment result report for the designed building. As Cx tasks, the location, skin structure, size and position of aperture in the building are optimized using a yearly simulation of natural room temperature.

In programming/planning phase of HVAC system, the planner presents the owner a comparison of environment and energy consumption among various alternative solutions by using simplified calculation tools such as yearly energy consumption estimate tool, LCC(Life cycle cost) (BELCA,1999) and LCA (Life cycle environmental load) (AIJ,2000). The role of simulation in Cx, is to validate the calculation results of the optimal solution presented by planner and to advise the owner on the rationality of the Owners Project Requirements using standard simulation tools approved by country or industry.

At the preliminary design phase, the designer calculates hourly and daily peak load by using MicroPeak (JBMEEA, 2000), selects HVAC and outdoor air introduction method, and decides the capacity of air conditioner and heat source equipment. It is necessary to confirm the indoor airflow and the

Table 1 Classification of various simulation tools

Purpose of use	Application phase	Typical simulation programs
Calculation of LCC, LCA	Program, Plan	Database for LC evaluation, LCA calculation program
Heat load calculation	Design	MicroHASP, MicroPEAK
Energy simulation	Design～Operation	HASP/ACSS, TRNSYS, EnergyPlus, DeST, ESP-r
Dynamic analysis of HVAC system	Design～Operation	HVACSIM$^+$, TRNSYS
Macro analysis of thermal environment in large enclosure	Design	DAIKUKAN
Analysis of air current and thermal environment	Design	Stream, Esim, Windy, FLUENT, CFD2000
Ventilation calculation	Design	COMIS, Ventsim, DeST, NETS(Okuyama,1998)
Water/ice thermal storage system design	Program, Design	TESEP_W, TES_ECO, Ice club(HPTCJ,2001,2003)
Soil thermal storage system analysis	Design～Operation	Analysis tool of Soil thermal storage system(Miyata)
Cogeneration system evaluation	Program, Design	CASCADEⅢ(SHASE,2003b)
Analysis of BEMS or measurement/ control system	Construction, Operation	Logic tracer

Table 2 Comparison of simulation for normal work and for Cx in each phase

	Application phase		Main examination items for supporting work to Cx	Main contents of simulation
Building	Plan/ Design	Normal	Design building location, envelop structure, aperture size etc., Calculate PAL and BEE	Calculate PAL and BEE with BECS,CASBEE
		Cx	Optimize building location, envelop structure, aperture size, and aperture position etc.	Simulate heat load and natural room temperature yearly
HVAC system	Program/Planning	Normal	Decide zoning, compare environment and energy performance of various alternative methods	Calculate yearly energy consumption, LCC, and LCA simply
		Cx	Verify the validity of design objective and rationale of optimal design method	Calculate yearly energy consumption, LCC, and LCA by using standard simulation program for Program/planning phase
	Preliminary design	Normal	Decide HVAC and heat source, estimate the equipment capacity, confirm indoor airflow and thermal environment	Calculate peak heat load by using MicroPeak, confirm airflow, thermal environment by CFD
		Cx	Optimize HVAC, heat source, equipment capacity, number division of equipment	Calculate hourly heat load through the year in detail
	Working design	Normal	Optimize various design parameters, decide equipment capacity and number, decide size of duct and pipe, analyze pressure balance and noise, evaluate indoor comfort	Optimize design parameters by using system dynamics characteristic analysis tool, analyze pressure balance and noise of duct and pipe, calculate PMV
		Cx	Confirm the design content and various optimal design parameters	N/A
	Construction/ Acceptance	Normal	decide size of duct and pipe, analyze pressure balance and noise, evaluate indoor comfort, confirm the control logic, optimize the control parameters	Analyze pressure balance and noise of duct and pipe, use BEMS and perform control logic simulation
		Cx	Verify function and performance of various equipments, systems, and BEMS (FPT)	System dynamic analysis by using actual equipment characteristic
	Post acceptance (one year)	Normal	Verify the performance of system, equipment and BEMS continuously, verify yearly indoor environment and energy consumption	Analyze energy consumption by using measurement data of BEMS
		Cx	Verify the function and performance of system, equipment and BEMS continuously, Verify environment and energy consumption in actual heat load and operation state, optimize control parameters	Analyze and evaluate environment, energy consumption and system dynamic characteristic in actual heat load state by using BEMS
	Operation	Normal	Optimize environment, energy consumption, and control strategy	Optimize the operation and control by using measurement data of BEMS
		Cx	Optimize environment and energy consumption, fault detection and diagnosis, diagnose equipment deterioration, verify the effect of energy conservation method and control technique	Analyze environment and energy consumption based on meteorological condition and indoor heat gain, simulate various operation and control pattern, fault detect simulation

temperature distribution by computational fluid dynamics (CFD) in large enclosures. As the work of Cx, use the energy simulation tool to calculate the hourly heat load and energy consumption performance, and present the information on the HVAC system and the optimal capacity of equipment which suits the demand of the owner.

In the working design phase, the designer examines various design and control parameters by using analysis tools for dynamic properties of system and equipment such as TRNSYS (SELUW, 1996) and HVACSIM^{+} (Daniel, 1985). Moreover, the pressure balance calculation of duct and pipe system, the noise analysis, indoor air current and the thermal environment is evaluated. The commissioning authority (CA) only needs to review and confirm the design calculations document and does not need to perform new simulations.

From the construction to post-acceptance phase, the constructor performs measurements and confirms the function performance of various equipment, systems, and the building energy management system (BEMS). Moreover, the behavior of the BEMS and the measurement/ control system can be confirmed in closed-loop by using Logic Tracer (Shioya, 2007) or other similar tools. As the work of Cx, it is necessary to confirm the yearly behavior of system or equipment including low load state, the energy consumption, and the indoor thermal environment by inputting system control parameters and actual equipment characteristics into the object system simulation model made at the working design phase.

At the operation phase, the operator confirms the function and performance of systems, equipment, and BEMS using measured BEMS data. The operator also performs statistical analysis of energy consumption data with the aim of optimzing operation control. As the work of Cx, simulations in some meteorological conditions and heat load states are performed to verify that the Owner's requirements for system function and performance are satisfied. When fault occurs in equipment operation or indoor environment, the fault cause and treatment are analyzed by using fault detection and diagnosis tools or energy simulation tools. Moreover, the effect of implementing energy saving techniques can be confirmed by comparing the simulation results with the measured BEMS data.

CHARACTERISTIC OF TOOLS REQUESTED TO SUPPORT Cx

In IEA ECBCS Annex 30, the retention of simulation information was emphasized to simplify the simulation input requirements and to maintain the consistency of simulation information when changing phases. However, the authors believe that it is not necessary to maintain the consistency of all simulation information because the objective and the purpose of Cx change in each phase. The reason is that information on the HVAC system and equipment gradually changes from unknown into already-known as the building/HVAC system lifecycle transitions from the planning phase through to the operations phase. It is necessary to give appropriate default value because much of the information in the program and planning phases is unknown. Information given as default value need not to be used when shifting to the design phase. Moreover, a lot of extant HVAC simulation programs have usage limitations because the input process to construct the model of building and system is troublesome and complex. In particular, there is no detailed data of HVAC system in program and planning phase.

If a simulation tool interface corresponding to Cx needs in each phase can be developed, the problem mentioned above, such as information flow, lack of data and usage limitation, can be solved. It is desirable to have a simulation tool that can easily change information inputs when requirements are inconsistent across phases, (for instance, the equipment performance feature used in design phase might be different from that delivered in construction phase). The following sections present needs for new tools or extensions to extant tools. Four kinds of support tools for Cx or visual tools of extant HVAC simulation programs are preferable for performing Cx in each phase.

Tool for Cx in program phase

A tool is needed in the program phase to provide default values of input data for standard building/HVAC systems under various applications. If total floor area, building usage, and standard skin specification were specified by the user, it would be possible to simulate the thermal performance of building skin and the energy consumption even when a lot of input data is not known. This kind of tool would be used mainly in the program phase when energy consumption, LCC and LCA are being evaluated.

Tool for Cx in planning phase

A tool that could use a building/HVAC system model to easily change the construction of building envelop and make alternative solutions of some HVAC and heat source systems is needed for the planning phase. By graphing the simulation results from each alternative case, the user could compare these graphs and easily analyze the thermal environment and energy performance of HVAC and/or heat source system of the object building.

Tool for Cx in preliminary design step

A tool that could be used to input details of simulation model of the HVAC system object after the default values of input data for simulation model construction are prepared is necessary for the design phase. This would enable the user to optimize the equipment capacity and various control parameters.

Tool for Cx in acceptance and operation phase

For the acceptance and operation phase, a tool is needed to construct simulation models of equipment and subsystems and to perform simulation using measure data of existing building. Furthermore, the tool could be used to change performance characteristic of various equipment easily. Using it, the user could calculate the performance and confirm the performance degradation of equipment units or subsystem, and could perform real time simulation for fault detection and diagnosis.

APPLICATION OF SIMULATION TOOLS

In IEA ECBCS Annex 30, the influence which simulation structure, computational algorithm of each component and user interface etc. exerted on the application of simulation was examined in detail. In this paper, when using extant simulation programs and visual tools for Cx, it is considered which Cx phase they correspond to according to program structure, default value and convenience of user interface. A comparison of the performances of typical HVAC system simulation programs or their visual tools developed is shown in Table 3. The application of these programs or visual tools for Cx in each phase is examined as follows.

Limitation of program structure

As the structure of many simulation programs is of a menu type, the model of new system and equipment cannot be added and calculated by users. A program based on module can solve this problem. The module types of program considered in this paper are HVACSIM+, TRNSYS, ACSES (Yoshida, 2006), and LCEM (Sugihara, 2006) only.

Presence of default value and corrective action

In many programs, the default values are not prepared for constructing calculation models. Hence, the lack of detailed data of the HVAC system makes it difficult to simulate at the program & planning phase. However, in FACES (Yanagihara, 2004) or eQUEST (James, 2003) (a public simulation engine of DOE-2), almost all of the default value of input data for standard building and HVAC system model construction is prepared. Therefore, even in the program and planning phase, if total floor area and building usage are specified, the simulation of the energy saving performance design is available. Typically, if Energy Efficiency Measure Wizard in eQUEST, which includes a Wizard with three levels (Schematic Design Wizard, Design Development Wizard, and Energy Efficiency Measure Wizard) and an interface for detailed data input (Detailed Interface), is used, nine alternative solutions can be easily generated. It is very convenient for comparison of alternative solutions and selection of the most suitable HVAC system at the planning phase.

In DeST, the “Idealization imitation type” function allows the user to calculate individually the values for building load, HVAC system, duct system, and the heat source system instead of preparing default values beforehand. This means that even if details of the HVAC system are unknown, the building load simulation becomes possible under the assumption that the building is being controlled by the ideal HVAC system and control method. This "Idealization imitation type" has the following advantages.

1) Energy simulation in program & planning phase is available because the upstream simulation is possible even if the system specification in the downstream remains unknown.

2) Because the system in the downstream does not influence the simulation of the system in the upstream, optimal design is carried out in order of building, HVAC system, and heat source system.

Correspondence to equipment unit and subsystem

Simulation programs other than the one which has a module structure such as HVACSIM$^+$, TRNSYS, ACSES, and LCEM cannot be used for simulation of equipment unit and subsystem. However, it is possible to calculate building, HVAC system, duct system, and heat source system individually by using DeST. In addition, it is possible to simulate existing building/HVAC system too with measured data through the improvement of the program. Therefore, DeST could be used to verify performance and to simulate faults in subsystems at acceptance and operation phases.

Correspondence to system dynamics analysis

According to the Cx purpose in each phase, the simulation purpose can be divided into energy simulation and dynamic analysis for system behavior. Since programs considered in this paper are static programs, only HVACSIM$^+$ and TRNSYS could be used for system dynamic analysis.

CONVENIENCE OF USER INTERFACE

It is very important to use simulation as indicated in the technical report of IEA ECBCS Annex 30. As a Cx support tool, functions such as simplification of model construction, visualization of the building/HVAC system, monitoring of on-line simulation with animation graphs, and the ability to generate diagrams of calculation result are preferable. The I/O (input/output) screen of typical simulation programs or visual tools is shown in Table 4 for Japanese programs and in Table 5 for programs developed in other countries. The convenience of each program or visual tool is examined as follows.

Convenience of construction of system model

In general, the user interfaces of the simulation programs are divided into CLI (command line interface) and GUI (graphical user interface). In CLI, there are numeric input processors with a prescribed format such as DOE-2 or HASP/ACLD/ACSS and interactive mode numeric input processors like HVACGEN for generating simulation models for HVACSIM+. Input mistakes occur easily with the former as there is no error check function for inputted data. Although the latter has an error check function for input data, correction of input data is complex.

Table 3 Performance comparison of HVAC system simulation programs and visual tools

Program name Developer Development(release) time	MicroHASP SHASE 1982	Micro/ACSS JBMEEA 1985	FACES NIKKEN SEKKEI 2005.3	LCEM PBA 2006
Program construction Module addition by user	Menu mode Impossible	Menu mode Impossible	Menu mode Impossible	Object mode Possible
Name of visual tool Developer Development(release) time	MicroHASP/TES HPTCJ, TOENEC 2005.3	ASSIST CEPCO 2005.5	GUI involving	Utilization of GUI in EXCEL 2007.3
Application phase of Cx	Elementary design	Design, Acceptance, Operation	Program, Planning, Design	Elementary Design, Operation
Building model creating method Visualization of building	Data input with GUI No	Data input with GUI No	Data input with GUI No	Developing No
Selection/composition of system Visualization of system	No No	menu selection Yes	Menu selection No	Equipment link No
Online animation graph	No	No	No	No
Program name Developer Development(release) time	TRNSYS Wisconsin Madison University 1975.3	DOE-2 Lawrence Berkeley National Laboratory 1980	EnergyPlus Lawrence Berkeley National Laboratory 2001.4	DeST Tsinghua University 2000
Program construction Module addition by user	Module mode Yes	Menu mode Impropriety	Module mode No	Menu mode Impropriety
Name of visual tool Developer Development(release) time	IISSiBat, SimCAD CSTB	eQUEST Jeff Hirsch, Associates 2001	DesignBuilder Design Builder Software Ltd 2006.1	GUI involved
Application phase of Cx	Design,Acceptance, Operation	Program～Operation	Design,Acceptance, Operation	Planning～Operation
Building model creating method Visualization of building	Drawing in SimCAD Yes	Data input in GUI Yes	3-D Yes	CABD Yes
Selection/composition of system Visualization of system	Component icon Yes	Menu selection Yes	Menu selection No	Menu selection No
Online animation graph	Yes	No	No	No

Note: The state of affairs in 2006.1 is that modules cannot be added by user with EnergyPlus, however the newest information about the latest version should be obtained from the homepage http://www.eere.energy.gov.

To address this issue, GUIs have been developed in recent years for many existing programs, and virtually all of the newly developed programs have a GUI. However, even for the same GUI, the higher the usage ratio of graphics, the more convenient it is deemed to be. According to the construction method of building/HVAC system model, GUI of various programs can be classified into three types as follows. a) GUI where data input and item selection are performed only by dialog box, b) GUI where visual screen of HVAC system and building skin specification and eaves configuration are added beside the dialog box for item selection and data input, and c) GUI where building model is constructed with 3-D drawing tool and HVAC system model is constructed through the connection of custom icons.

The HVAC system construction processors of BECS, FACES, DesignBuilder, and DeST belong to type a). Because there is no visualization screen of HVAC system, readability of the composed HVAC system is poor and it is difficult to correct the simulation model generated. The building model construction processors of Micro/HASP (SHASE, 1982), ASSIST, BECS, and FACES belong to type b). Readability of the model generated improves because the specification of building skin and eave are displayed on the visualization screen. Moreover, although eQUEST constructs the building model by item selection with dialog box and numeric input, a 3-D display function of the building by AutoCAD is provided after the building model is generated; the building model can be confirmed by sight.

Advanced simulation programs with the function of illumination calculation, the shade calculation of adjacent building (i.e., DeST) and visual tool (i.e., DesignBuilder, the visual tool of EnergyPlus) belong to type c) because building model construction function with 3-D drawing tool is provided. Because the building model is constructed almost totally with the mouse in these programs, the construction work of the building model is very convenient. On the other hand, even for the programs that do not relate to building configuration, like the HASP (Inooka, 2005) series program or DOE-2 used to calculate load only, the function whereby the generated building model can be confirmed by sight is desirable for visualizing the building. Therefore, a 3-D display of the building function was added to simulation engine eQUEST of DOE-2.

As the HVAC system model construction function based on the relation of the components is provided in ASSIST, visual modeling tool of HVACSIM+ (J) (Yamatake-Honeywell, 1996), eQUEST, and IISSiBat, it is very convenient to construct and check the model.

Output format of calculation result

The output format for calculation results were reviewed for each simulation program. The format of the calculation result of BECS and HVACSIM+ is very inconvenient because output is text file only. Other programs the output function is a diagram of the calculation results, which is very convenient for arrangement/comparison of calculation results. In particular, as the report and diagram of HVAC system proposal etc. are automatically generated in FACES, the arrangement of calculation result is almost unnecessary.

Moreover, TRNSYS and ACSES have a function monitoring calculation result in real time using animation graphs. The verification time for simulation models is greatly shortened because the user may have the calculation discontinued ahead of time if calculation results become unfeasible or if the calculation becomes an infinite loop.

Limitation of language used

It is difficult to spread those programs developed in foreign countries in Japan because the I/O operations screen only displays in a foreign language. Therefore, the development of visual tools in Japanese is preferable. A Japanese version visual modeling tool of HVACSIM+ (J) has already been developed. Moreover, Japanese version visual tools of TRNSYS and EnergyPlus are currently under development (Anonymity B, Tetsushi, 2005). Furthermore, a Chinese β version visual tool of EnergyPlus was developed by TianJing University (Liu,2005).

CONCLUSION

This paper presented the results of an investigation and comparison of the program structure, default value treatment, and convenience of user interface of several HVAC simulation programs. It also proposed four kinds of tools that are necessary to support each phase of Cx. Various simulation programs and visual tools have the different strengths as follows:

1) construction of programs
2) treatment of default value
3) correspondence to equipment unit/subsystem
4) correspondence to system dynamics analysis
5) convenience of I/O operation of user interface
6) limitation of language

The application of the various tools to each phase of Cx is also different.

Moreover, when these tools were used as support tool for Cx, the main applicable Cx phase was also considered. Realistically, large-scale energy simulation programs are used generally at Cx phases after preliminary design and simpler programs or powerful I/O interfaces are used more often in program and planning phases.

The eQUEST, simulation engine of DOE-2, includes three Wizards with three levels and a detailed interface. In using the Schematic Design Wizard, Cx simulation is possible in the program phase as the default value of many input items is supplied. Moreover, additional simulation tools like DeST, which was developed considering performance verification, would be useful for each step of design.

Using DeST, natural room temperature, heat load, energy consumption of HVAC system, duct system and heat source system could be calculated individually and the calculation of equipment unit/subsystem using measured data of existing buildings and HVAC/heat source systems can also be performed.

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Table 4 Comparison of I/O performance of user interface of various simulation programs (Japan)

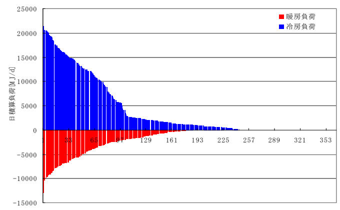
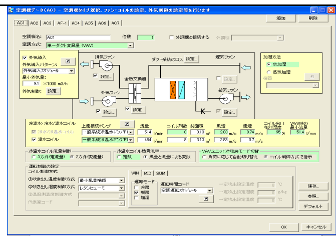
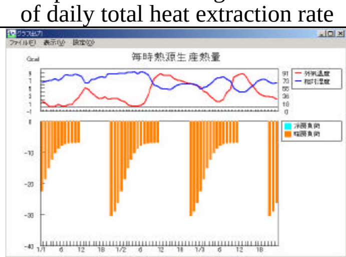
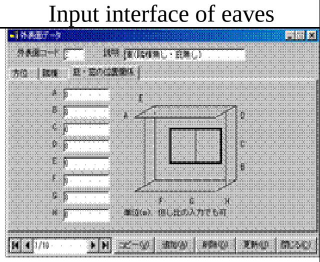
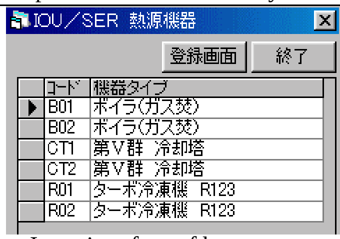
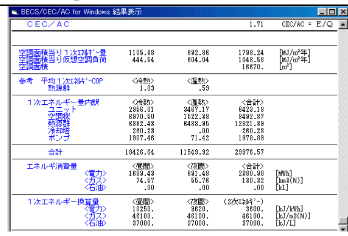
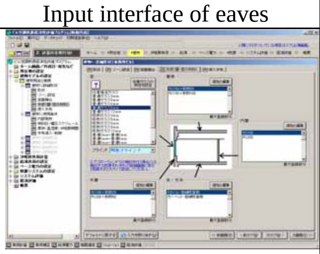
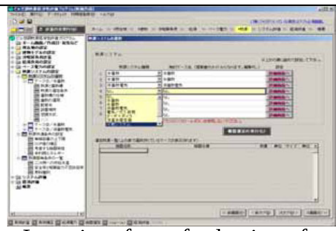
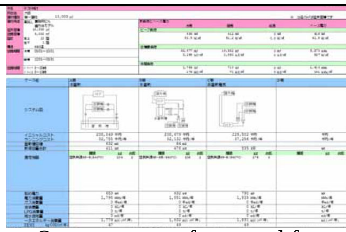
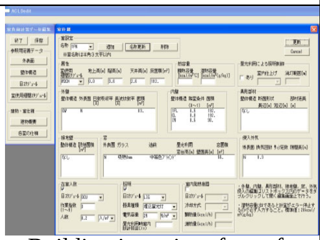
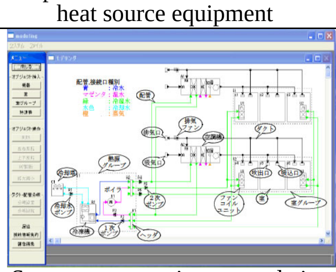
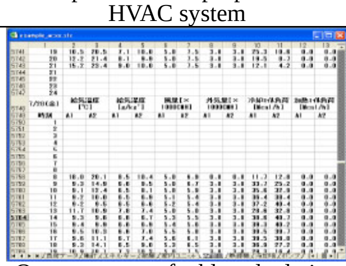
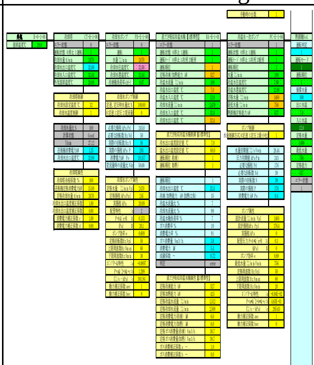
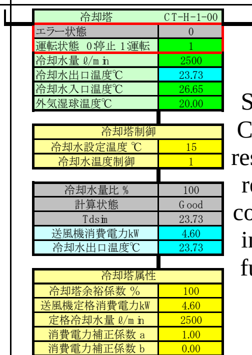
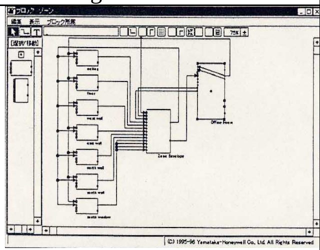
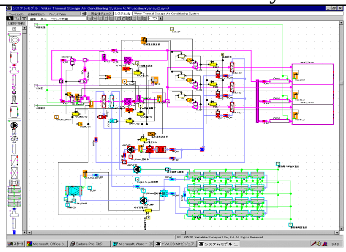
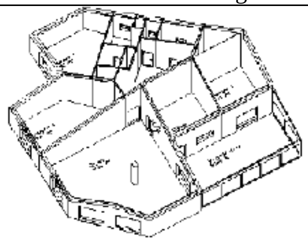
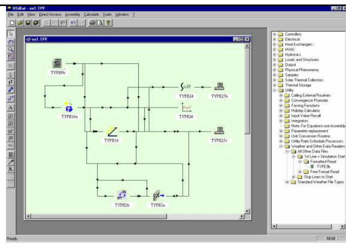
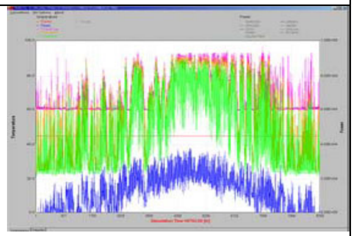
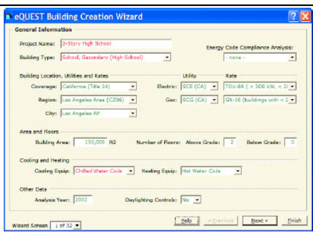
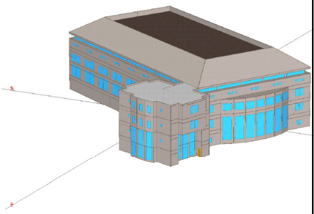
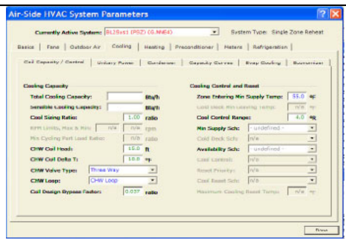
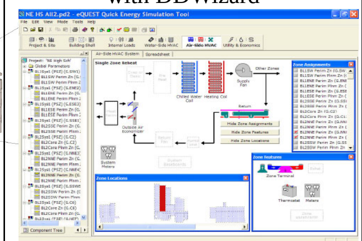
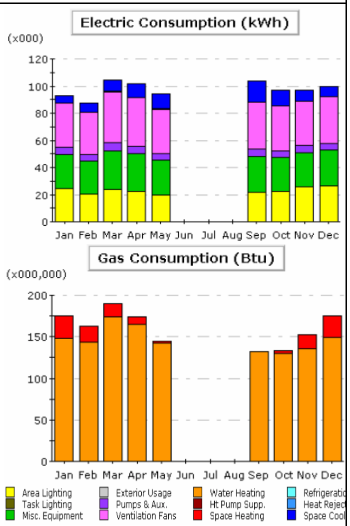
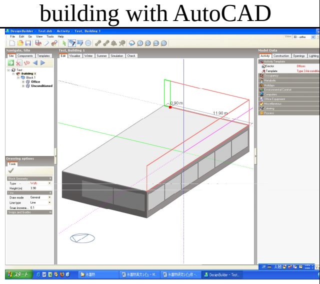
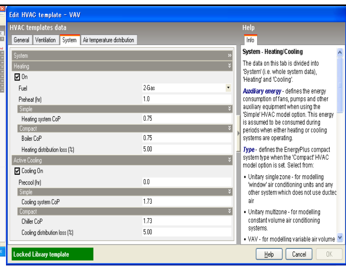
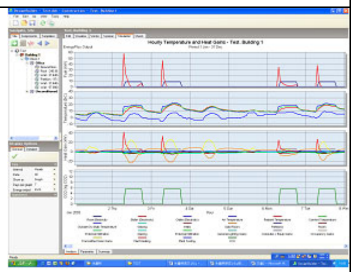
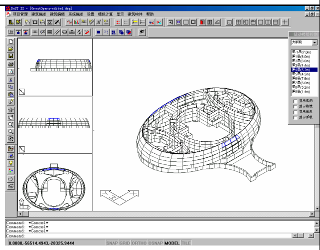
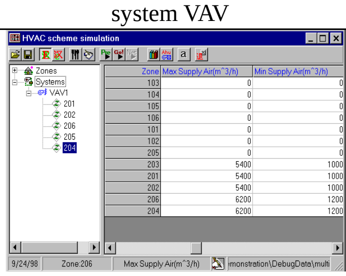
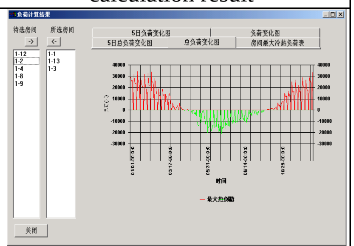
Name	Building model construction	Selection/construction of system	Output of calculation
MicroHASP (SHASE,1982) Micro HASP/TES (Toenec Corporation, 2005)	 Input interface of eaves	No	 Output of descending order chart of daily total heat extraction rate
Micro/ACSS (Kato, 2004) ASSIST (Systech Environment Lab,2005)	 Input interface of eaves	 Input interface of HVAC system	 Output screen of heat source
BECS (IBEC,1994)	 Input interface of eaves	 Input interface of heat source	 Output screen of text data
FACES (Yanagihara, 2004)	 Input interface of building skin	 Input interface of selection of heat source equipment	 Output screen of proposal for HVAC system
HASP/ACLD /ACSS (SHASE,1985) GUI (Hiroyuki, 2004)	 Building input interface of ACLDedit	 System construction example in ACSSmodeling	 Output screen of table calculation result
LCEM (Sugihara, 2006)	The building load is given as a boundary condition.	 Construction example of heat source system	 Show Calculation result in cells, result consolidating in EXCEL function Calculation result output screen in EXCEL

Table 5 Comparison of I/O performance of user interface of various simulation programs (foreign country)

Name	Building model construction	Selection/construction of system	Output of calculation
HVACSIM+(J) (SHASE,2003) Visual modeling tool (Yamatake-Honeywell,1996)	 Input screen when constructing multi room building	 Input interface of HVAC system	It is possible to convert output text data to the CSV type with output convert subroutine
TRNSYS (SELUW, 1996) IISSiBat SimCAD (Anonymity B)	 Drawing of building model with SimCAD	 Input interface of HVAC system with IISSiBat	 Online animation graphical representation of calculation result
DOE-2 (James,2001) eQUEST (James,2003) Schematic Design Wizard Design Development Wizard Energy Efficiency Measure Wizard Detailed Interface	 Input interface for outline of building with DDWizard  Example of 3-D displaying of building with AutoCAD	 Input screen of HVAC system with DDWizard  Input screen of Detailed Interface	 Output example of EEM Wizard
EnergyPlus (Anonymity) DesignBuilder (Anonymity A)	 Three-dimension drawing of building model	 Input screen of VAV HVAC system VAV	 Graphical output screen of calculation result
DeST (Jiang,2004)	 Construction example of	 Input screen of VAV HVAC	 Graphical output screen of

	building with CABD	system	calculation result