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Energy analysis for building designers through computer software

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Abstract—The paper deals with an optimization of the energy consumption of buildings and its management and controlling through computer simulation. This contains comparative study of energy consumption in a building. It also includes an overview of the basic components necessary for energy analysis of buildings using the impact of various affecting factors. Also, factors influencing human comfort are also taken into consideration. On the whole, a relative study of the current energy scenario with respect to simulation software's has been carried out. An insight into the global energy crisis has been provided.

I. INTRODUCTION

Thepaper is focused on how energy can be conserved using computer simulation software's, which enables building designer to optimize the energy management at preliminary design stage. Energy conservation is very tedious task for building designers at an early design phase. Computer simulation is somewhat the solution of this problem so as to meet the future energy demands. Energy is something that cannot be created nor be destroyed but can only be transformed in various forms for the better use of humanity. Energy is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms.

According to the law of conservation of energy, the total energy of a system remains constant, though energy may transform into another form. Two billiard balls colliding, for example, may come to rest, with the resulting energy becoming sound and perhaps a bit of heat at the point of collision. The SI unit of energy is the joule (J) or Newton-meter (N * m). The joule is also the SI unit of work. About 35 percent of the primary energy used in developed countries is used to heat, cool and light buildings or in other hand are utilized within building. The energy used by the building sector continues to increase, primarily because new buildings are constructed faster than old ones are retired. Electricity consumption in the commercial building sector doubled between 1980 and 2000, and is expected to increase

The role of simulation tools in the design and engineering of buildings has been firmly established over the last two decades. Simulation provides speeding up the design of process, platform for qualitative comparison, increases efficiency and which in turn gives the optimal design. Energy performance simulation programs are powerful tools to study energy performance and thermal comfort during the building's life-cycle.

Today, numerous such tools are available and they differ in many ways; in their thermodynamic models, their graphical user interfaces, their purpose of use, their life-cycle applicability, and their ability to exchange data with other software applications. Energy simulation tools predict the energy performance of a given building and thermal comfort for its occupants.

In general, they support the understanding of how a given building operates according to certain criteria and enable comparisons of different design alternatives. Energy simulation is very useful to optimize the thermal human comfort within the building. Human thermal comfort is a combination of a subjective sensation (how we feel) and several objective interaction with the environment (heat and mass transfer rates). Comfort depends on several physical magnitudes that we may group as-

i. Person-related. Deep body temperature, always close to 37 ºC (may depart a few degrees under unhealthy circumstances, like with fever). Metabolic dissipation rate; we must evacuate unit body mass some 0.5 W/kg to 5 W/kg, depending on activity. Skin temperature is usually below 33 ºC, allowing the heat evacuation, but it depends a lot on external conditions, clothing, and actual and previous activity levels. Besides, previous accommodation (e.g. changing from indoors to outdoors), habits (e.g. clothing difference among seasons and sex), personal preferences (some people feel comfortable cold or hot), and actual mood (the state of mind, feeling happy or nervous) may have an influence (comfort is not just a physiological problem but psychological too).

ii. Environment-related. Air temperature (or water temperature if diving), background radiant temperature (of walls, sky, and Sun, if any), air relative humidity, and wind speed. And not only average values but gradients and transients. The most difficult to measure of the parameters governing thermal comfort is the background radiant temperature, which depends on direct solar irradiance, wall solar reflectance (albedo), sky temperature, wall temperature, and all the geometric view factors involved.

II. GLOBAL ENERGY CRISIS

The energy consumption of buildings is about 35-40% of the world's total energy consumption. The analysis of consumption of energy by buildings is a complex task and also of great importance seeing the global energy crisis. Heating, Cooling and lighting account for a major portion of the consumption, in both types of buildings, residential as well as commercial. Other minor energy consumers are mentioned in detail in the figure 1a.

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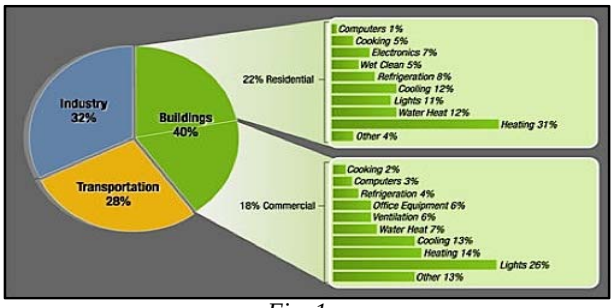


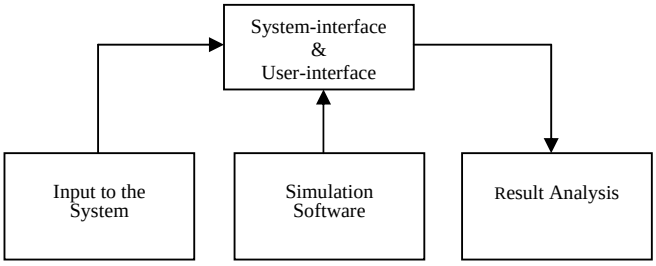
Fig. 1a

With the ever-increasing demands in large-scale human comfort and ease, the energy consumption is also increasing day-by-day. To compensate for the same, we have to utilize our convention fuel reserves such as coal, gas, oil etc. At the same time, we have to keep the initial and running costs within the allocated financial resources. Also, extensive research should be done on the number of ways in which energy can be generated using intelligent building design.
Keeping in mind all of the above factors, it depends greatly on the design engineer to perceive and analyze the scenario of energy consumption, distribution and utilization in order to develop a system which satisfies all the critical parameters involved.

III. HOW COMPUTERS ARE HELPFUL IN ENERGY MANAGEMENT OF BUILDINGS

Energy consumption in buildings is a complex function of various external and internal parameters, which need to be properly identified, analyzed and categorized to form a useful system-base to calculate the minimum amount of energy required for a building to survive efficiently. This can prove to be tedious if the calculations are done manually, whereas the computers are capable of doing that very accurately. There are numerous factors which affect the energy consumption of a building such as weather, location, material etc. Any software, which is designed to simulate the effect of these parameters accurately, must have all the formulae and relations integrated into its database. The results should be displayed in 3D graphs. The software must be assured quality-wise and it should offer efficient integration of simulation expertise and tools in the overall building process. The overall schema required for any computer-aided building design software must have the following elements –

i. System-interface and User-interface
ii. Input to the System
iii. Software for simulation
iv. Result Analysis



1. Weather database
2. Location database
3. Material database
4. Building-type database
5. Building-profile database

IV. OVERVIEW OF SOME SIMULATION SOFTWARES

1. BLAST

   The Building Loads Analysis and System Thermodynamics system can be used to predict energy consumption, energy system performance and costs in buildings. This system includes all the loads on the system to evaluate the thermodynamic behavior of the building such as infiltration loads, internal sensible and latent heat gain, outside air sensible and latent heat gain etc. Broadly BLAST contains three phases: Building load prediction thermodynamically, design of air system and the central plant. This software can be used to investigate the energy performance of retrofit building of almost any type.

2. Bsim

   This software is widely used for energy design and moisture analysis. The earlier name of this software was tsbi3.This is very user friendly software. It also provides hydrothermal simulations of buildings. This software contains many modules which are extensively used today.

3. DeST

   This software allow us to analyze the building in detail with respect to thermal processes and system performance. It is also known as Designer's Simulation Toolkits. It can handle complex problems very effiecientlty.Some specified versions of this software are used in China for various large projects. It comprises various modules out of which very common is CABD[Computer Aided Building Design] which uses CAD interface.

4. DOE- 2.1E

   This Software is composed of one major subprogram and four simulation programs. The output of first program becomes the input to the second program and so on. This software is used very commonly in USA since 20 years. The major difference between this software and others is that

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it accepts hourly data and also provides printed hourly reports.

5. TAS
   This software works on dynamic simulation of building which includes both natural and forced air flows. It also has separate input assembly which is based on CAD to facilitate the 3D graphic input. This software is being used in UK and around the world since 20 years. It also provide simple 2D CFD package.

6. IDA ICE
   This software provides modular systems a platform to analyze using symbolic equations . Indoor Climate and Energy[IDA ICE] provides simulation language that is Neutral Model Format[NMF] for the developers for intregrated user interfaces.

7. eQUEST
   It is an advanced version of DOE-2.2 , which provides easy working of designer to simulate the energy requirement in designing the buiding.It is also hourly based system which simulates the performance of building based on walls, windows, glass, people, plug loads, and ventilation. It provides high quality results.

8. HAP
   Hourly Analysis Program, provides simulation package with two tools: sizing of system and hourly energy analysis of system. This is used extensively by practicing engineer to, facilitate the efficient work of determining loads. Results can be expressed in both tabular and graphical form. Part load applications are very easily done with this software.

9. Energy Express
   It is created by CSIRO, used to determine cost and energy consumption at the pre stage of design. This also contains a dynamic multi Zone heat transfer to enhance the simulation technique. Energy Express software is useful for both architects and engineer. It provides a strong base to simulate the model of building structure very easily and to sort the problem effectively. Being dynamic in nature it gives good results on heat transfer analysis.

10. PowerDomus
    This software is used extensively to analyze both thermal comfort and energy use simultaneously. It contains combined model of heat and moisture transfer. PowerDomus allows users to visualize the sun path and inter building shading effect to effectively simulate the model. It includes both capillary migration and vapour diffusion effects.

11. SUNREL
    SUNREL is an hourly building energy simulation program that facilitates the user to design the buildings where loads are dominated by heat transfer phenomenon between building and environment. It provides easy multi zone airflow algorithm to determine the infiltration and natural ventilation .

12. TRACE 700
    TRACE is composed of four sub classes: Design, System, Equipment and Economics. All the divisions have their respective work which in turn simulates the total energy requirement of building keeping cost as the limiting factor. All the loads on the building are estimated in the design process and finally compiled with remaining three processes by doing some fixed hour test simulation.

13. TRNSYS
    This software provides the transient system simulation to solve complex problems by breaking them into simpler components. It provides detailed building model in order to solve system of algebraic and differential equations. It also provides TRNSYS library which aims on renewable sources systems such as fuel cells etc.

14. IES<VE>
    The IES<VIRTUAL ENVIROMENT> is an integrated set of programs interlinked to a common user interface and a single data model. This software includes model drawing, load assignment, thermal analysis and many more applications. It also provide base to optimize the problem with regards to thermal comfort and energy use.

15. HEED
    This software is very user friendly and designed such that it provide fast computational speeds high quality graphics, ease of use, wide range of input data etc. HEED requires only four inputs to

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execute: floor area, number of stories, location, and building type.

16. ESP-r
    It is a multi domain, well built, software which is in service since 25 years and is used extensively for the complex geometries, controlled by the user interface. It also supports an explicit energy balance for each domain.
17. EnergyPlus
    It is based on the most specialized features of BLAST, which enables us to provide various input data through the interface and which in turn is simulated to form meaningful results. It also provide users to evaluate moisture adsorption and desorption in building elements etc

18. ECOTECT
    This software is very intense in regards with the visual design and permits to solve complex shapes very easily, covering thermal, energy, lighting, shading, acoustics and cost aspects. It also provides provision for feedback at very early stage to facilitate robust design.

V. CONCLUSION

The design of a building is a multipara metric problem with both objectives and constraints. The papers enlist various computers software's available in the field of building energy analysis. The use of the computers helps the building designers to overview of results obtained by different combination of parameters. This is useful in choosing solution to a given problem. The optimization process gives the direction in which the considered parameters have to be chosen considering the objectives and constraints.

Computers based methods are used in an impressing and exciting ways in various fields of architecture such as advanced geometry and computer -aided production methods .New tools make it possible to design and actually built forms that would not be possible without the use of computers. These powerful methods have to be actually design better buildings, not only better looking ones.

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