IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
ISSN(e) : 2278-1684, ISSN(p) : 2320–334X, PP : 09-12
www.iosrjournals.org

Analysis of Energy Simulation Softwares to Enhance Energy Efficiency of New and Existing Buildings

Aditya Punia[1*], Sanjay Sharma[2], Poonam Syal[3]
[1]*Department of Civil Engineering, NITTTR Chandigarh,*
[2]*Department of Civil Engineering, NITTTR Chandigarh,*
[3]*Department of Electrical Engineering, NITTTR Chandigarh*

Abstract: *Buildings consume nearly one third of the total annual electrical energy consumed in the country and are one of the largest contributors, second only to industrial sector to greenhouse gas emissions. Energy demand is expected to grow aggressively in the coming years with rising population and technology intensive lifestyles. So, to ensure that this demand is met in a sustainable way, it is necessary to make the buildings extremely energy efficient and curb the energy footprints associated with them. This can be achieved by using energy modelling/simulation for all the upcoming buildings and also for existing buildings to provide retrofitting measures to make them more energy efficient. The suitability of a given tool or software for energy simulation will vary depending on specific needs and circumstances. The factors which affect the suitability of the simulation tools for different buildings are the ease of data input interface, availability of results in graphical form and usability for code compliance. This paper discusses the various energy modelling/ simulation tools which are available today. The suitability of these tools according to the building type, the climate zone in which the building is located in and what major component of the building is to be simulated will be assessed.*

Keywords*: Energy efficiency, simulation, energy modelling, building envelope, HVAC*

I. INTRODUCTION

Indian economy has expanded aggressively in the last few decades and it is poised for greater growth in the future. However, our progress is accompanied with unique local and global challenges. Rapid economic growth, urbanization and expanding population have imposed a great strain on energy supply resources. The need for smart, green, and sustainable cities is apparent from the Agenda 2030 for Sustainable Development, adopted in 2015 [6]. Buildings consume nearly one third of the total annual electrical energy consumed in the country and are one of the largest contributors, second only to industrial sector to GHG emissions. With about 70% of the buildings which will be required in 2030 yet to be built, this sector is going to drastically impact any efforts to contain GHG emissions [7]. Energy demand is expected to grow aggressively in the coming years with rising population and technology intensive lifestyles. India has committed to reduce emissions intensity of the national GDP by 33% to 35% by 2030 from 2005 level [9]. Transformation of the building sector to the most advanced standards of building energy efficiency like Net Zero Energy Buildings (NZEBs) is crucial for achieving these targets.

In 2007, the worldwide urban population exceeded the rural population for the first time in history [5], as can be seen from Fig. 1. This demographic change started in the 1950s, with people migrating from rural to urban areas. The obvious reason for this was the availability of professional, social, economic, and personal growth opportunities the urban environments were offering. In 2014, 54 percent of the total world population was urban occupants. The world population along with those living in urban areas are expected to rise. Such an increase in population comes with substantial challenges and difficulties in urban environments, which will soon become incapable to meet the basic needs in a sustainable manner. One of such challenges is to be able to meet the ever-increasing energy demands of these urban environments. This calls for adopting the highest possible standards of energy efficiency and switching slowly to renewable energy sources. This demographic change in the scenario has resulted in growing inefficiency levels and calls for an overhaul of the urban environments by sustainable planning [4].

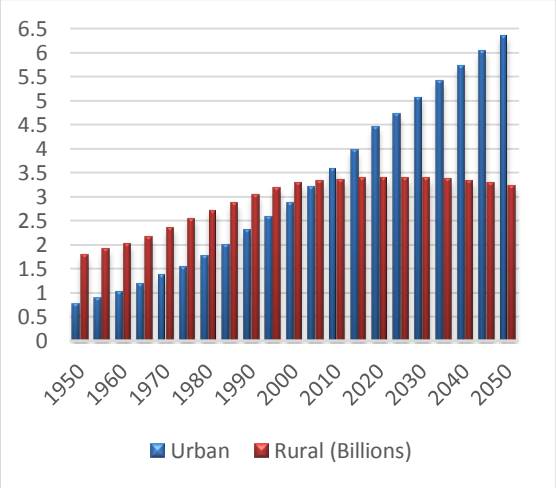

Fig. 1 Urban and rural population worldwide.

II. OBJECTIVE

This paper presents an overview of different software/tools which are available for energy modelling of buildings. The major components of a building which need to be assessed for energy efficiency are building form i.e. shape and orientation, building envelope i.e. window dimensions and wall to window ratio, internal loads i.e. lighting power density and plug loads, HVAC systems i.e. size, efficiency of system and the schedules of the building. Different softwares have different interfaces and calculation engines and work best only for some and not all the components listed above in a given set of environmental conditions.

This review is being carried out to find the major benefits and drawbacks of energy modelling softwares for different building components.

III. ENERGY MODELLING

An energy model is nothing else but a calculation engine accepting inputs such as geometry of the building, operation schedules, and system characteristics, to produce outputs like graphical performance comparisons and compliance reports. Energy modelling is helpful in energy efficient designing of a building because it is an iterative process, in which fundamental design parameters are addressed in initial models, and feedback on the performance of building form and orientation and how they will affect the buildings energy efficiency is provided as models develop. Just one percent improvement in the energy efficiency of HVAC systems adds up to millions of dollars in annual savings at the international level [1]. The guide to good practices in operating ICT devices [2] and actionable feedback from occupants [3] have shown the immense energy-saving potential of over 130,000 kWh and 311 kWh annually respectively.

The advantages of energy modelling are that it enables designer to articulate energy as a component of efficiency, assists in the development of building envelope taking into account insulation types, solar heat gain coefficients, and thermal properties, helps quantify potential reduction in energy use and associated greenhouse gas emissions, reduced and more predictable operating and maintenance costs, greater degree of occupant comfort due to better control of envelope radiant losses and gains and reduced infiltration, energy modelling helps understand the impact of material choices on comfort [8].

Some of the disadvantages of energy modelling are that it is highly detailed and requires advanced skill, lack of staff dedicated to energy modelling, energy modelling takes time and resources, energy considerations may sometimes limit design decisions.

IV. REVIEW OF SOFTWARES

Today many different tools for energy modelling of buildings are available each having their own set of pros and cons. The suitability of a given tool or product varies according to specific needs and circumstances. While selecting a tool for a specific project, the things to be looked for in a tool before final selection are the ease of use of tool, the support for various passive design strategies in it. Time and cost required to work with the tool are also important factors to be considered. Interoperability remains another factor which cannot be ignored as the tool will have to work with already existing building design tools such as AutoCad and Revit etc. The types of inputs available and how does the tool accept them and in output how does the tool generate graphs, charts, comparative analysis or just numbers and it is also important how easy are outputs to understand. In the end, how accurate results are generated by the energy modelling tool should be given due consideration before arriving at the final selection of the tool.

Some of the tools which are available and widely used for different applications in energy modelling are DOE-2 (engine), EnergyPro, Green Building Studio (GBS), eQUEST, Energy Plus (engine), DesignBuilder etc. The details of each of these programs is discussed below and a comparison is done in Table 1.

DOE-2 is a calculation engine for Building Energy Modelling developed by Lawrence Berkeley National Laboratory, it calculates life cycle costs and energy performance of whole building projects. DOE-2.1E and DOE-2.2 are the two versions of this tool which are available. It provides detailed and hourly energy analysis for multiple zones of buildings of both simple and complex design. It supports simulation of buildings with fully mixed HVAC systems, such as variable air volume systems. However, this calculation engine is not frequently updated now and also requires a high level of user knowledge.

EnergyPro uses DOE-2.1E engine as an interface to carry out whole building energy modelling calculations and also for code compliance. In this program, the input and output forms are simple and easy to understand. However, it doesn't provide a 3D building model as a frame of reference to understand the code compliance reports and it isn't free to use.

Green Building Studio (GBS) links 3D CAD building designs AND Autodesk architectural building information models (BIM) with energy, water, and carbon analysis. It uses DOE-2.2 engine to calculate energy performance and generates geometrically precise input files automatically for major energy simulation programs. This is a cloud-based service using large capacity computing power to manipulate a variety of parameters. and get results quickly. However, the automatically generated details don't allow for manipulation of building components and it is also not free to use.

eQUEST is the most widely used graphic interface which uses DOE-2.2 engine. Its interactive graphics, wizards, parametric analysis, dynamic defaults, and rapid execution makes eQUEST able to conduct whole building energy simulation analysis. It has a schematic design wizard, a design development wizard, and a fully detailed input mode which address different user experience and expertise and it is also free to use. The building geometry can also be imported from other softwares, such as BIM. As eQUEST is freeware, support for software related questions is limited and online public fourms are required for that purpose.

TABLE I COMPARISON OF ENERGY MODELLING TOOLS

Modelling Tool	Calculation Engine	Graphic Interface for Front-End Input	Graphic Results Provided	Appropriate for Early Design Phase	Approved for Code Compliance Modelling	Freeware
EnergyPro	DOE- 2.1E	No	No	No	Yes	No
Green Building Studio (GBS)	DOE- 2.2	Yes	Yes	Yes	No	No
eQUEST	DOE- 2.2	Yes	No	Yes	Yes	Yes
Design Builder	EnergyPlus	Yes	Limited	Yes	Yes	No

EnergyPlus is a Building Energy Modelling tool for existing buildings, new construction, low-energy designs and conventional buildings. It provides better accuracy and enables analysis of complex building designs and mechanical systems. Many interfaces have been developed which are linked to the EnergyPlus engine to enable users to analyse radiant systems, natural ventilation, ground source heat pumps and complex HVAC systems with overall building design. It provides more detailed simulation results for newer system technologies and is a freeware. However, it is significantly slower when compared to other engines because of enhanced physical modelling details.

DesignBuilder offers an interactive and user friendly energy modelling environment. It can accommodate wide range of data such as environmental performance, internal comfort data, energy consumption, and HVAC component sizes. Sub hourly time steps are used for simulation to generate output. It is a simple and most intuitive interface currently available for EnergyPlus engine. However, there is no import function for building geometry, so all the detailed modelling has to be done within the interface, it has limited ability for accurately simulating complex HVAC systems and it is not a freeware.

V. CONCLUSIONS

After carrying out the above analysis of various tools available for energy modelling for buildings, we can conclude that all the energy modelling/simulation interfaces are based on some calculation engines which can be DOE- 2.2, DOE- 2.1E or EnergyPlus. EnergyPro can be used if only code compliance reports are to be generated as it doesn't provide 3D models. GBS can be used if accurate BIM models of buildings are to be simulated and for generating geometrically accurate input files for EnergyPlus. eQUEST maybe used when continuous energy modelling is required from the planning to the execution stage as details can be changed easily in its wizards. DesignBuilder is used for very detailed sub hourly energy performance analysis but it is

slower as it uses EnergyPlus engine. To be able to make our buildings more energy efficient and our planet more sustainable, awareness about energy modelling/simulation must be created among designers and engineers.

REFERENCES

[1]. Shoureshi, R., "Intelligent control systems: Are they for real?" Trans. ASME, vol. 115, pp. 392–401, 1993.
[2]. Kamilaris, A., Ngan, D.T.H., Pantazaras, A., Kalluri, B., Kondepudi, S., & Wai, T.K, "Good Practices in the Use of ICT Equipment for Electricity Savings at a University Campus," 5th International Green Computing Conference (IGCC), pp 1-11, 2014.
[3]. Kamilaris, A., Neovino, J., Kondepudi, S., & Kalluri, B, "A Case Study on the Individual Energy Use of Personal Computers in an Office Setting and Assessment of Various Feedback Types Towards Energy Savings. Energy and Buildings,"104, pp 73–86, 2015.
[4]. "Untangling Smart Cities," https://doi.org/10.1016/B978-0-12-815477-9.00002-5.
[5]. "World Population Prospects: The 2017 Revision, Key Findings and Advance Tables," ESA/P/WP/248. United Nations. 2017 https://esa.un.org/unpd/wpp/publications/Files/WPP2017_KeyFindings.pdf. , last accessed 2020/05/10.
[6]. "Sustainable Development Goals," https://sustainabledevelopment.un.org/ , last accessed 2020/05/12.
[7]. "Global Status Report," Towards a zero-emission, efficient, and resilient buildings and construction sector, UN Environment, 2017.
[8]. "Integrating Energy Modelling in the Design Process," The American Institute of Architects, 2012.
[9]. "India's Intended Nationally Determined Contributions – Towards Climate Justice," Ministry of Environment, Forest and Climate Change, Government of India. 2020.