



Validating the performance of the HVAC system for commercial buildings

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Abstract

Commercial Buildings consumes a large amount of world's energy. Energy components comprises of Lighting, Heating, Cooling, Ventilation, water heating etc. To make the building energy efficient, we need to maintain, monitor and apply thermal optimization. Numerous researchers over the world are chipping away at vitality demonstrating and control with a specific end goal to create techniques which will bring about general decrease of vitality utilization. This paper presents the workflow of the energy modelling HVAC (heating, ventilation and cooling) system which proved to be the complete solution for low energy buildings. Also the estimation of the thermal load which helps in validation of architectural design for energy efficient buildings.

Keywords: Building Energy Simulation, Energy Plus Software, HVAC System, Building Information System.

1. Introduction

These days, building vitality utilization speaks to the most vital part of the worldwide utilization which affect altogether to environmental change. This vitality utilization brings about emanation of CO₂ in awesome sum. To decrease this vitality utilization and condition affect we require a vitality displaying and

reproduction demonstrate which require more examinations on vitality execution and vitality demonstrating of structures. The principle objective for such vitality proficient structures is to compute the warm load and after that to assess and approve the compositional outline and HVAC framework in 2D or 3D. In buildings, energy consumption is mainly due to lighting, heating, cooling, ventilation, water heating, office equipment, Refrigeration, computer, cooking and others. Main load of

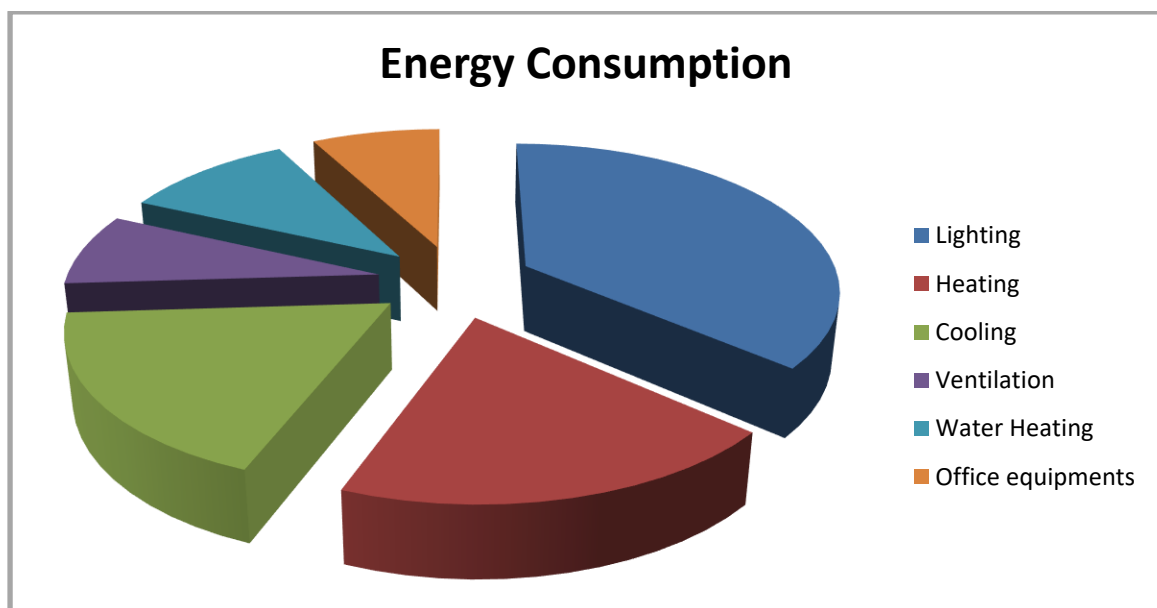


Fig. 1: Energy consumption in the buildings

power consumption is due to the HVAC system in both residential and non residential buildings. Figure 1 represents the energy consumption of the building. And also depends on the indoor and outdoor conditions of the buildings which need to be monitored periodically.

The key advance for vitality observing and keeping up of a working to comprehend its different subsystems to assess and break down the significant parameters. Different parameters with a specific end goal to assess open air conditions are:

1. Outdoor Temperature
2. Outdoor Relative Humidity
3. Wind Speed and Direction
4. Global Solar Radiations

5. Atmospheric pressure

Similarly various parameters in order to evaluate indoor conditions are:

1. Indoor Temperature and Relative Humidity
2. Building Pressurization
3. Air Intake and Exhaust
4. Internal Heat Gain(Occupancy levels ,Equipment Densities , Lighting levels)
5. Zone Criteria

For the greater part of structures observing of temperature (hourly esteems) and sun based radiation (day by day) can be adequate. Different parameters are fitting, and now and again mandatory in extraordinary case (e.g. normally ventilated structures).

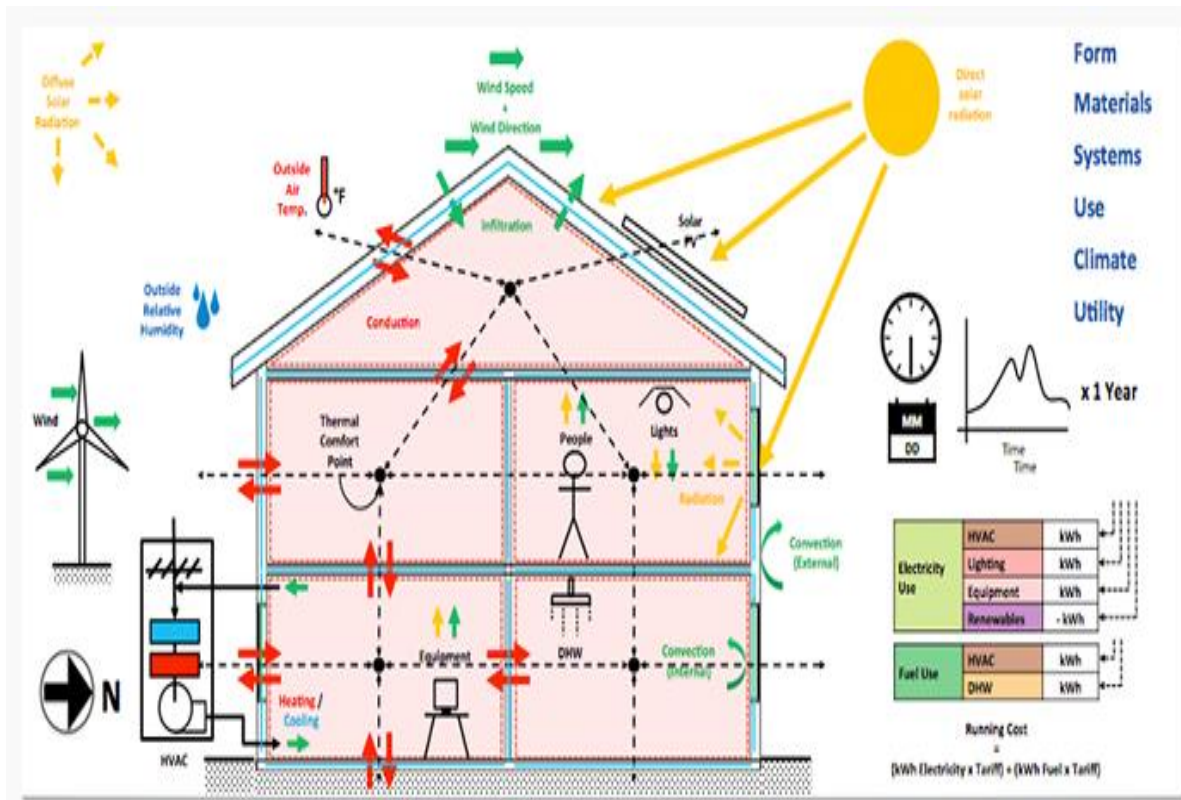


Fig. 2: Outdoor and the indoor conditions affecting the energy efficiency of the building.

The figure 2 shows that how the outdoor conditions impact the energy efficiency of the building. To assess the warming and cooling limits, we need some data with respect to the indoor and the open air conditions, particulars of the building, determination of the adapted space, (for example, inhabitancies, different hardware utilized) detail of the material required, area and introduction and so forth. The HVAC System in typical commercial buildings composed of various components and equipments arranged in sequence in order to preserve the quality of air inside the building which directly impacts the indoor conditions. The types of HVAC subsystems are:

A. An Air handling Unit (AHU): This Unit is in charge of conveying the adapted air in encased space in the building. In business structures there are number of frameworks which conveys this air. These are:

- i. Constant Air Volume (CAV)
- ii. Variable Air Volume (VAV)
- iii. Low Flow Air Diffusers
- iv. Fan Powered VAV
- v. Raised Floor Air Distribution.

B. An Air cooling unit (Chillers): This Unit is utilized to supply the cool air to the AHU. In plugs structures, there are gadgets which is utilized to create cool water are called chillers. The water is pumped to AHU to cool the air. They utilize both mechanical refrigeration procedures and retention forms.

C. An Boiling unit (Boilers): This unit is utilized to create steam or heated water and can be terminated by gaseous petrol, fuel oil or coal. The accompanying Boilers have burning productivity between 78% to 86%.

- i. Firetube Steel Boilers
- ii. Watertube Steel Boilers
- iii. Cast Iron Boilers

For simulating the actual load characteristics (heating and cooling capacities) of the HVAC system, each of the sub-systems are mathematically modelled.

2. Literature Review

Here, we show a contextual investigation to exhibit Warm Vitality Storage (TES) of a focal chiller plant in late spring which gives the most extreme power heap of the vitality. We first utilize the deliberate information to align the parameters of the framework demonstrate. At that point, the framework display is developed in the MATLAB condition. A TES procedure is contrasted and a standard methodology through MATLAB re-enactments.

In this, a chiller plant of a grounds with vast quantities of building is taken. A pool of chillers is utilized which give high operational adaptability. These may have numerous practical operational mode, for example, ON/OFF modes, i.e. chiller would be able to

turned ON with most extreme supply of water supply For this, TES can be utilized to check the grounds cooling burden and pinnacle rate.

TES is charged by the chiller plant in the evening time when the power load and cooling requests are low and is released in the day time when the request is on top. The objective of the chiller plant is to upgrade the TES plant, to limit the power utilization and to fulfill the cooling request. The general vitality productivity and the adequacy of the chiller plant relies upon the execution and the working of the controls in levels of the TES.

The target of this is to locate the ideal set focuses to limit the operational cost and vitality utilization of working the chiller plant and the chiller bank. With the developing enthusiasm for ideal control, the quantity of plans was created to spare vitality of the chiller plant in TES. The ON/OFF planning succession for chillers and charging/releasing choices is created by blended whole number non-straight programming problems(MINLP) can be figured at each progression for TES.

A heuristic calculation is utilized to scan for the imperfect arrangement of the MILNP issues by linearizing the framework flow with settled TES operational profile. The model jumble because of linearizing can be remunerated by the moving skyline plot. In this way strategy helps in deciding the vitality proficient chiller plant of the grounds.

3. Tool for Energy Modelling System

Energy modelling system for energy low buildings involves monitoring and management of various sub-systems to evaluate and analyze the parameters.

3.1 Monitoring of HVAC Systems

Heating and cooling load calculations:These are done to appraise the required limit of warming and cooling frameworks, which can keep up the required conditions in the molded space. To appraise the required cooling or warming limits, one needs to have data with respect to the plan indoor and open air conditions, determinations of the building, details of the molded space, (for example, the inhabitancies , different machines and office hardware utilized and so on.) and any uncommon prerequisites of the specific application. For comfort applications, the required indoor conditions are settled by the rule of warm solace, while for modern or business applications the required indoor conditions are settled by the specific procedures being performed or the items being put away.

Warming burden counts are completed to assess the warmth misfortune from the working in winter to touch base at required warming limits. Regularly amid winter months the pinnacle warming burden happens before dawn and the open-air conditions don't shift essentially all through the winter season. Moreover, inside warmth sources, for example, inhabitants or apparatuses are valuable as they repay a portion of the warmth misfortunes.

For any working there exists an adjust time when the sun based radiation(Q_{solar}) and interior warmth age rate (Q_{int}) precisely adjust the warmth misfortune from the building.

$$(Q_{solar} + Q_{int})_{sensible} = UA(T_{in} - T_{out})$$

where UA is the result of general warmth exchange coefficient and warmth exchange region of the building, T_{in} is the required indoor temperature and T_{out} is the open air temperature. From the above condition, the outside temperature at adjusted condition ($T_{out,bal}$) is given by:

$$T_{out,bal} - T_{in} = (Q_{solar} + Q_{int})_{sensible} / UA$$

Presently, there are sure conditions on which we need to choose whether to cool the building or warmth the building. In the event that the open air temperature is more prominent than the adjusted outside temperature given by the above conditions, i.e. $T_{out} > T_{out,bal}$, then there is a need of cooling the building and when it is not exactly, i.e. $T_{out} < T_{out,bal}$, at that point there is a need of warming the building and when $T_{out} = T_{out,bal}$, at that point there is no requirement for either cooling or warming the building.

For business structures with huge inward loads and generally littler warmth exchange zones, the adjusted open air temperature can be as low as 2°C, suggesting a long cooling season and a little warming season. On the off chance that there are no interior warmth sources and if the sun powered radiation is immaterial, at that point from the warmth adjust condition, $T_{out,bal} = T_{in}$, this suggests if the outside temperature surpasses the required inside temperature (say, 25°C for comfort) at that point there is a requirement for cooling generally there is a requirement for warming. Therefore, relying on the particular states of the building, the requirement for either cooling framework or a warming framework depends. This likewise infers a requirement for advancing the building protection relying on open air conditions and building heat age so one can use amid specific periods free cooling gave by nature without utilizing any outside cooling framework.

3.2 Modeling the HVAC System

The three most vital parts of the HVAC framework were displayed are:

- A. AHU
- B. Chiller
- C. Boiler

These units are ascribed with a few parameters (which client can design in the application's Graphical Client Interface) which have been characterized in table 1 and which were utilized to portray the framework demonstrate.

Table 1: HVAC components and parameters for modelling of energy efficient building.

| Components | Parameters | Unit |
|------------|---------------------------------|-------|
| AHU | Start time of Operations | Hours |
| | Indoor temperature set point | C |
| | Air flow type | |
| | Power Rating | kW |
| Chiller | Rated Power of Compressor | kW |
| | Rated Power of Water Pump | kW |
| Boiler | Rated Power of the Heating Coil | kW |
| | Rated Power of the Water Pump | kW |

3.3. Implementation

Based on the above methods, a system model is build which helps in modelling the energy efficient building architectural model. The idea behind this model is to estimate the energy load and utility rate such as electricity rate, real time pricing rate, sample with all utilities etc, satisfying the cooling/heating demands.

The High level business flow diagram for the proposed model is shown below.

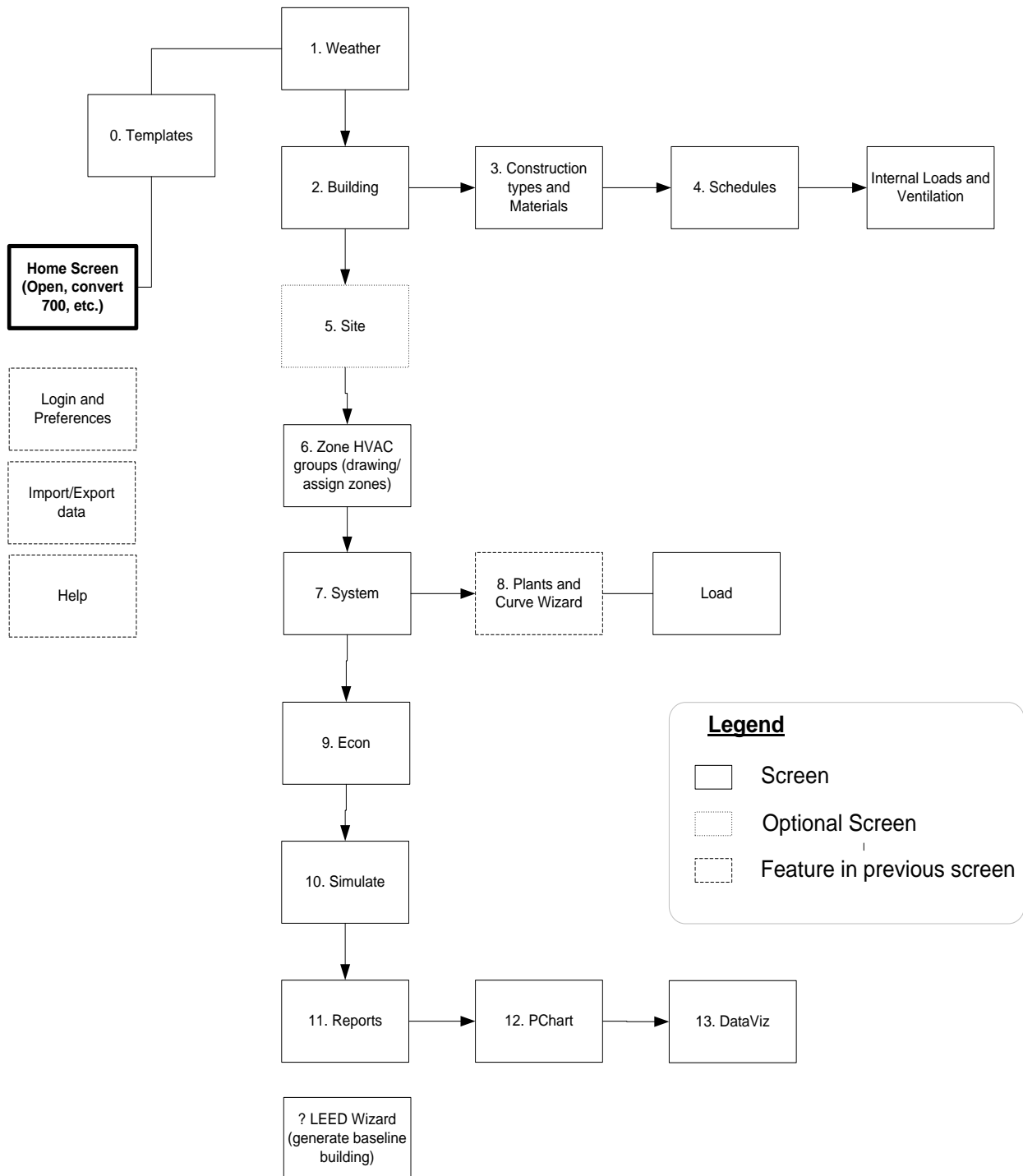


Fig. 3: High level business design of the building modelling system.

In this system model, most of energy consumption is due to the HVAC subsystems i.e. AHU unit, chillers and Boilers. Now, each module in the system represents the sub modules each performing the specific task. The sub module Template includes Airflows, Internal load, Building Construction, Room types, Zone types etc. Using Weather sub module, select the location for the building module affecting outdoor conditions. Next comes deciding the construction, Building types such as education sector(school, colleges), food service(restaurants), health care(hospitals, pharmacy), industrial, lodging(hotels), retail etc and the material. Further deciding the internal load (room type, ventilation, occupancy etc. At that point comes choosing the HVAC framework and after that at last reproduce the sub modules for limiting the vitality utilization and the power cost, fulfilling the cooling/warming requests.

The above system helps the architects and the architects to decide the foremost plan criteria of a building. To increase the operational functionality and performance of the above proposed model, a simulator tool was developed using the GUI which validates and estimate the thermal utility for the energy low buildings. The test system and GUI together go about as a Human Machine Interface (HMI). A little change in input parameter changes the overseeing states of the framework and in this way the qualities and the framework parameter estimations of the building outline. The working of real-time energy modelling and simulation model is considered to design the simulator. The major input to this simulator can be already created building design model saved in Test Foundation Server(TFS) as an build or any new building model, designed manually selecting from the libraries.

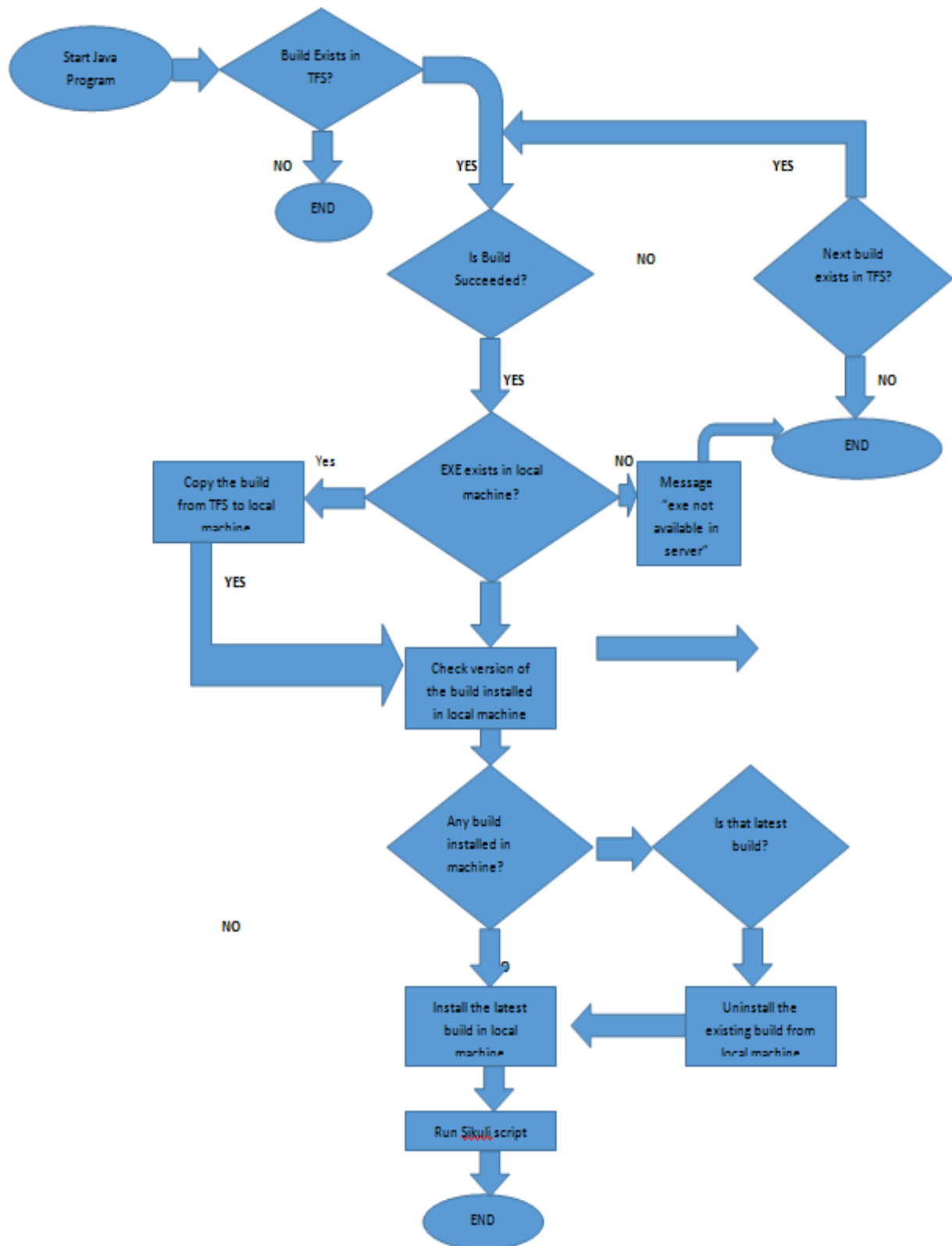


Fig. 2: Block Diagram for Automation tool for Trace 3D Plus

The systematic workflow of the simulator is described in figure 2 to compare and validate the energy efficient building designs. It first checks whether the build exist in TFS (Test Foundation Server) which includes all the .exe files related to the build. If the build exist in the TFS then checks whether the build is succeeded or not. If yes it set up the .exe file in the local system and checks for the version of the build. If the build is not of latest version, it re-installs the latest version.

Once the latest build is installs in the local machine, it runs the entire modules in a sequence automatically based on the sikuli scripts selected. After this, the simulator checks the various parameters and compares the energy efficiency of the build and validates the architectural design module. After the validation of the designing modules, it generates a report or result which shows all the parameters and the respective energy consumption values, these reports also shows the error. Based on errors, the build can be modified and be validated again in span of few hours.

4. Conclusion

This paper presents the methods for optimizing the building temperature based on the outdoor and the indoor temperatures and various other parameters. These methods compute the exact temperature for vitality building reproductions.

Besides, this envelope display must be utilized for re-enactment as well as relevant for streamlining. It will be additionally utilized for indoor temperature forecast and warming/cooling control, with respect to the warm solace and the vitality productivity. Moreover, it helps to design and validate the performance of the architectural design for energy efficient buildings.

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