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# Impact of Climate Change on Operational Energy Consumption of Building Envelop at Bhopal

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**Abstract:** ***Building envelop is a combination of structure element i.e. wall, roof , window, door etc. The role of building envelop is to provide comfort to its occupants. Building envelop provide comfort to the habitants by creating boundary between external and internal climate. Electromechanical equipment are used to create desired comfort conditions. These electromechanical equipment need energy for their operation. This paper investigates the impact of climate on energy requirement for operation of electromechanical equipment used for creating comfort condition in the building. In this study eQUEST software is used to quantify the operational energy used by the building envelop in climate of year 1990,2020,2050 and 2080 placed at Bhopal (M.P.) India. The simulation report shows different quantum of operational energy requirement in different climatic condition when a building envelop is placed in a particular climatic condition.***

**Keywords:** Building Envelope, Energy, Energy Efficiency, Energy Efficient Building Envelope, Sustainable Building Envelop.

## 1. Introduction

Over the years human being developed building envelop to address climatic condition to provide suitable comfort condition. To provide comfort condition a set of electro mechanical equipments are used which consume energy. Building envelope's impact on energy consumption should not be underestimated: globally over one-third of all energy consumed in buildings (1). Depleting fossil fuel reserve and use of these fossil fuel to produce useable form of energy has created environmental problem. This derived professionals to understand interaction between energy, climate change and its relation with Building envelop.

Climate indicates the weather condition prevailing over the area over the years. The observed changes in India's climate reveal that there is an increase of 0.56 °C in the temperature for the country as a whole over the past century (1901-2000) against the globally observed increase of 0.76 °C. However, there is no significant long term trend in monsoon rainfall or floods in the summer monsoon season at all India level. The total frequency of cyclonic storms forming over Bay of Bengal has also remained almost constant over 1887-1997 (2). It is projected that, by the end of 21$^{st}$ century, rainfall in India may increase by 15-40% with high regional variability. Warming may be more pronounced over land areas with northern India experiencing maximum increase. The warming could be relatively greater in winter and post-monsoon seasons. The annual mean temperature could increase by 3 °C to 6 °C over the century. The rise in sea level in the north Indian Ocean has been observed to be in the range of 1.06-1.75 millimeters per year in the past century. There is a threat of coastal inundation in some of the low lying coastal areas. (3)

The purpose of this study is to investigate relation between energy consumption by the building envelop with changing climatic condition in Bhopal (India). The study is carried out using eQUEST energy simulation software by placing a building envelop in Bhopal (India). different climatic condition projected for 1990,2020,2050 and 2080.

## 2. Literature Review

Building provide thermal and visual comfort by interacting with its surroundings with or without electro-mechanical means. In this process energy is used. The building energy demand will change in response to future climate change, with this cooling and heating demand will also change. The annual cooling loads in buildings will greatly increase in all building sectors and in all climate regions of the country. There is a corresponding decrease in heating loads due the climate warming, but this decrease does not compensate for the increase in cooling demand except in the coldest region of the United States, and for only the residential sector (4).

Haojie & Chen (5) investigated cooling energy use through simulation of energy plus in buildings in 15 different U.S. cities located in seven climate zones. The energy simulation showed that the impact of climate change varied greatly among different types of buildings. It is concluded that The majority of the cities located in Climate Zones 1–4 (Marine, Hot humid, Warm humid& Mixed humid ) in would experience a net increase in source energy use for cooling and heating by the 2080s, while cities in Climate Zones 6 and 7 (cold & Very cold) would experience a net reduction in source energy use. and By the 2080's, the effectiveness of natural ventilation would be greatly reduced by global warming in some cities, such as San Diego (having marine climate).

Nine sample office buildings in Vienna, Austria are studied for both heating and cooling demands under current and future climatic conditions are calculated and compared. In this study it is concluded that Cooling demand in this building is continuously increasing by 39% in study period of 30 Years. The Heating demand is high initially but it decreases by 26% over the 30 years (6).

Study aimed to quantify how changes in the UK climate in the coming decades will have a direct effect on heating and cooling energy use in future office environments (i.e. by the year 2030) and also seeks to inform future choices for

supplying energy to office buildings - in particular, micro generation options. It confirms the importance of dealing with demand-side changes before assessing the supply-side opportunities, with buildings having very different heating and cooling needs post-refurbishment. The study also highlights the importance, and possibilities, of adapting to future climates, and the benefits of promoting heating-dominated buildings instead of cooling-dominated.(7)
Studies on the impact of climate change on energy use in buildings in the different parts of the world were reviewed. In this it is concluded that The most significant impact on energy use in the built environment would occur in the hot summer and warm winter climates where building energy use is dominated by cooling requirement. This would result in a shift towards more electrical demand and could have important implications for the nationwide energy and environmental policy for the built environment. (8)

## 3. Simulation Tool-eQuest

Buildings are constructed for long time. It is need of the day to design building taking into consideration operating cost, energy efficiency and sustainability. It is a great challenge to visualize all above while designing. Hence there is need of a energy simulation tool. Building energy simulation is used as a tool in the design of buildings, for determining compliance to building standards, predicting building's energy load and for the economic optimization of building components.

Energy consumption in this study were derived by using eQUEST energy simulation software version 3.0. eQUEST is developed by James J. Hirsch and Associates, USA, it is free for download.

***eQUEST is*** a whole Building Performance Tool which is ***introduced by Bureau of Energy Efficiency India*** (USAID ECO-III, 2010). ***eQUEST 3.6 version*** has been selected for this simulation study. eQUEST stands for QUick Energy Simulation Tool, uses an extended version of the simulation engine in DOE-2, the widely reviewed and validated industry standard for detailed whole building performance modeling, and uses wizards and graphics to make the experience user friendly. *eQUEST* is designed to provide *whole building performance analysis to* buildings professionals, i.e., owners, designers, operators, utility & regulatory personnel, and educators. *Whole building analysis* recognizes that a building is a *system of systems* and that energy responsive design is a creative process of integrating the performance of interacting systems, e.g., envelope, fenestration, lighting, Hinting Ventilation Air Conditioning( HVAC) and Domestic Hot Water (DHW). Therefore, any analysis of the performance consequences of these building systems must consider the interactions between them. in such a manner that is both comprehensive and affordable (i.e., model preparation time, simulation runtime, results trouble shooting time, and results reporting). eQUEST allows users to perform energy simulation but without requiring extensive experience in the "art" of building performance modeling and simulation.
All the project information is input through the wizards. Inputs can be provided at three levels: schematic design wizard, design development wizard, and detailed (DOE-2) interface. In the wizards, all inputs have defaults (based on the California Title 24 building energy code).

The Building Creation Wizard helps the user design a model of the building based on building plans and specifications at either schematic or detailed levels, and the Energy Efficiency Measures Wizard allows the user to designate up to ten design alternatives to the "base" building (multiple parametric design alternatives are also available for those working through the optional detailed interface). On completion of the simulation, with the help of a range of automatically generated individual and comparative graphs, utility consumption and cost savings for the efficiency measures can "be used to determine simple payback, life-cycle cost . . . and ultimately, to determine the best combination of alternatives.

## 4. Methodology

The methodology used in the project has the following steps:

- Accusation of weather data and modification of weather data file to match the requirement for simulation.
- Freezing of building specification
- Preparation of schedules for occupancy, lighting, HVAC and Hot water ETC
- Develop a detailed building energy simulation model of the case using eQUEST
- Study of outcome and presenting it in meaningful form.

The whole study is conducted in two parts

**i. Development of Weather Data**
The weather and climatic data required for this study are drawn from website of US department of Energy. The data is available for year 1998 in Energy Plus weather format as extension .EPW. But the software need weather data in .BIN format for this the data available in EPW format is converted into BIN format using eQUEST Weather Format Convertor.
The weather data available on the web site of EnergyPlus Energy Simulation Software (Website: EnergyPlus) is for year 1990. This study is considering the impact of climate change in future hence future weather data for year 2020,2050 and 2080 are generated using climate change weather file generator (CCWeatherGen Version 1.4). The climate change world weather file generator (CCWorldWeatherGen) allows to generate climate change weather files for world-wide locations ready for use in building performance simulation programs. It uses Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report model summary data of the HadCM3 A2 experiment ensemble which is available from the IPCC Data Distribution Centre (IPCC DDC) (1,2). The tool is Microsoft® Excel based and transforms 'present-day' EPW weather files into climate change EPW or TMY2 weather files which are compatible with the majority of building performance simulation programs.

**ii. Building Simulation method**
Energy consumption were derived by using eQUEST energy simulation software version 3.0. eQUEST is developed by James J. Hirsch and Associates, USA, it is free for download.

eQUEST able to conduct whole-building performance simulation analysis. Simulation is done using **Schematic Design Wizard of the software by** describing the building's architectural features and its heating, ventilating, and air-conditioning (HVAC) equipment. e-QUEST calculates hour by hour building energy consumption over an year i.e. 8760 hours using hourly weather data for location under consideration. Once the simulation is over the software provide estimated operational energy consumption on annual or monthly basis in the form of graph.

## 5. Building Data

**Stations considered for simulation**
Choice of station is made in such a way that it is located at center of India in Composite climate zone of India

**Simulation Input**
For simulation and analysis a 2 story fully air-conditioned rectangle building having width to length ratio 1:1.5 size of buildings are100 feet x 150 feet i.e.30.48 m x 45.72 m respectively has been considered. The ground floor area of the building is 15000 sq.feet i.e. 1393.54 Sqmt. Total floor area of the is 30000 sq feet i.e. 2787.10 Sqmt .
For simulation building with following Specification of building component is considered :
**Building envelop construction**
**Roof Surface**
**Construction:** 6" Concrete
**Exterior finish or colour:** Felt or bitumen: uncoloured
**Exterior Insulation:** No ext board Insulation
**Additional Insulation:**
**Above grade wall**
**Construction:** 8" CMU
**Exterior finish:** Brick
**Colour:** White gloss
**Exterior Insulation:** No board Insulation
**Additional Insulation:** Solid Grouted
**Interior Insulation:** No Furred Insulation
**Ground floor**
**Exposure:** Earth contact
**Construction:** 4" Concrete
**Ext/Cav insulation:** No perimeter Insulation
**Interior finish:** Ceramic tile/Stone
**Building Interior Construction**
**Ceiling:** Plaster
**Insulation:** No Insulation
**Vertical wall:** Mass
**Insulation:** No Insulation
**Floors**
**Interior finish:** Ceramic tile or stone
**Construction:** 2" Concrete
**Rigid Insulation:** No board Insulation
**Concrete cap:** No light weight concrete cap

**1) Equipment Parameters**

a) Cooling source is Direct Expansion (DX) coil and heating source is electrical resistance. Ducted air return path system is split system single zone DX with electric system.
b) Infiltration is taken as 3 air change per hour
c) Heating Ventilation and Air Conditioning (HVAC): Temperature and air flow System

| System | | |
|---|---|---|
| Thermostat set point | Occupied | Un- Occupied |
| Cooling Set point | 76 $^{o}$F | 82 $^{o}$F |
| Heating Set point | 70 $^{o}$F | 64 $^{o}$F |
| Design temperature | Indoor | Supply |
| Cooling Design temperature | 75 $^{o}$F | 55 $^{o}$F |
| Heating Design temperature | 72 $^{o}$F | 95 $^{o}$F |
| Air flow | | |
| Minimum design air flow | 0.5 cm/ ft$^2$ | |

## 6. Results & Analysis

Fig.1 shows annual energy consumption when building is placed at different climatic condition predicted for 1990,2020,2050 and 2080.

From the this study it is concluded that there is impact of climate on energy consumption of building envelop. Taking 1990 as base year. The is increase in energy consumption by 4.31% in time period 1990-2020, 9.54% in time period 1990-2020 and 17.68% in time period 1990-2020,

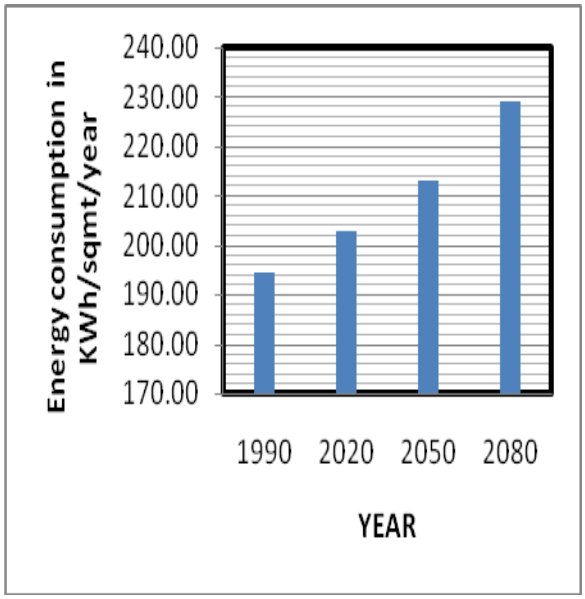


**Figure 1:** Annual energy consumption by building envelop in different years placed in Bhopal

## 7. Conclusions

From the above text it is concluded that building's energy consumption behavior of a building envelop changes with climatic conditions**.** Hence it is recommended to design building envelop taking future climate change into consideration.

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