Develop the climatic condition ratio for typical building in India

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Abstract. Diverse climatic condition influences building performance. It results in varying levels of energy utilization and Carbon dioxide emission. The building’s energy performance will also fluctuate based on climatic conditions. Thus comparing buildings in a range of climatic zones will lead to unjustified outcomes. It is of utmost importance to know what range the climatic conditions can impact a building’s energy performance. To improve the precision of building assessment rating tools, the climatic condition ratio is developed for various climatic regions of India by performing energy simulation on the typical building.

1. Introduction

Since the 1980s, GBRS have become a significant issue in the construction industry [1]. Globally, the count of Green Building Rating Systems (GBRS) is rapidly increasing, application of these for confined regions are getting progressively critical for giving a solid assessment on the specified built environments [2]. GBRS, the investigation finds that they have a lack in their building execution proportion or potentially framework that shows the distinctions coming about because of different climatic conditions [2]. This can incite out of line building appraisals when contrasting between two buildings in two diverse climatic zones. In this way, it is fundamental to perceive to what degree the climatic conditions can influence a building’s performance, is climatic condition ratio. The building assessment tool has to account for renewable energy, sustainability and energy efficiency [3].

The developed countries have the following GBRS, Green Star in Australia, Building Research Establishment Environmental Assessment Method (BREEM) in United Kingdom (UK) and Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan [4]. The primary GBRS in India are the Bureau of Energy Efficiency (BEE), Green Rating for Integrated Habitat Assessment (GRIHA) and Indian Green Building Council (IGBC) [5]. Bureau of Energy Efficiency (BEE) is a star scale (1-5) rating. Energy Performance Index is taken into ruminatation by BEE for certification. India’s Own rating system is GRIHA. It is been established by The Energy and Resources Institute (TERI) and the Ministry of New and Renewable Energy, Government of India. IGBC has developed GBRS for a wide category of buildings in line with the US Green Building Council (USGBC). It is an organization that enhances sustainability by providing Leadership in...
Energy and Environmental Design (LEED) credits to declare as green buildings. The motivation behind these GBRS in built environment is to enhance sustainable development [6].

Whether it is to attain BEE stars, GRIHA certification or LEED credit points for a building, energy efficiency is a major criterion for assessing building performance. For the operation of a building and maintaining some comfort zone to the occupants’ certain amount of energy is required [7]. The energy required and consumption rates vary due to various factors like types of materials used for construction, solar shading, the impact of climatic condition and potential gains of renewable energy. Hence this can instigate unfair building evaluation when buildings from various zones are compared [2]. So in this research, climatic conditions are considered to obtain climatic condition ratio and thus enhance the reliability of the building rating tools.

Green Building Studio (GBS) is the only tool which supports 3D CAD/Building Information Modeling (BIM), early design analysis, energy standard for buildings, Industry Foundation Class (IFC) Complaint, required outputs which comprises of annual energy consumption, peak electrical demand, life cycle energy consumption, on-site energy generation from wind systems and photovoltaic (PV), water use analysis, carbon emission [8]. Early design analysis ensures guidance to design, construction and maintenance phases.

The scope of this research is limited only to the climatic conditions of India. India has a wide range of weather patterns. Different regions have divergent climates. The climatic zones of India stretch out to semi-arid, arid, tropical wet, tropical wet and dry, subtropical and montane. New Delhi falls under the category of Semi-Arid. It is situated in the Northern Plains of the Indian Subcontinent. The Thar Desert and the Himalayas greatly influence the climate of New Delhi. It experiences 5 seasons’ namely spring, summer, rainy, autumn and winter. Jaipur represents the arid climatic condition of India which is located at the eastern border of Thar Desert. It experiences short monsoon, warm dry winters, and hot/dry summers. Thiruvananthapuram stands on the banks of river Karamana and Killi. It does not experience distinct seasons because it lies on the borders of tropical savanna climate and tropical monsoon climate. Chennai has a tropical wet and dry climate. The weather is hot and humid because it lies on the thermal equator and thus it restricts the seasonal temperature variations. On the northern Gangetic plains of India, Lucknow is located which is subjected to a humid subtropical climate. Summer, monsoon and winter are the major seasons in this city. Gangtok is situated in the eastern Himalayan region. It sustains 5 distinct seasons which include spring, summer, rainy, autumn and winter shown in figure 1.

![India Climate Zones](image)

**Figure 1. India Climate Zones.**

2. **Research Method**

To develop the climatic condition ratio, a G+6 residential building in 6 various climatic zones across India is considered.
2.1. The Necessity of a weather file:
Weather files contain a large section of hourly variables, for various different weather measurements. The climatic parameters impact the simulation results are they determined by the weather file. The climatic parameter includes:

- Atmospheric pressure
- Solar altitude
- Wind – speed and direction
- Dry and wet bulb temperature
- Moisture content
- Cloud cover
- External humidity

| CLIMATIC CONDITION            | LOCATION CHOSEN |
|-------------------------------|-----------------|
| Tropical wet and dry          | Chennai         |
| Semi Arid                     | New Delhi       |
| Arid                          | Jaipur          |
| Humid Subtropical             | Luck now        |
| Mountane                      | Gangtok         |
| Tropical wet                  | Thiruvananthapuram |

Steps to get started with Energy Analysis:
- Model your project
- Specify Project Location
- Define energy settings
- Simulate
- Analyze Results
- Check results in cloud
- Discussions
- Conclusions

The plan sketched in Autodesk Revit software and then the energy model is been created for the building. The same energy model is been analyzed for the 6 different locations in the green building studio by converting it into a gbXML file to obtain the total annual energy and total energy costs. The utility rates are been reset. Electric cost is ₹ 8.00/kWh and fuel cost is set to ₹125.00/Therm. While considering the PV production, the electric cost is set to $0.11/kWh and 20.4% $3.47 - panel type was chosen. Electric transmission losses are not considered for the estimation of total annual energy and cost. 30year of a lifetime is considered for the buildings in the process of evaluating the total annual energy and costs at 6.1% discount rates for costs. Test locations shown in table 1.

3. Results and discussion

| ZONE | LOCATION       | ELECTRIC (kWh/year) | FUEL (Therm/year) | TOTAL ENERGY (kWh/year) | PV PRODUCTION (kWh/year) | PERCENTAGE OF SAVINGS (%) |
|------|----------------|---------------------|-------------------|--------------------------|--------------------------|---------------------------|
| I    | Chennai        | 495570              | 3813              | 607290.9                 | 383031                   | 36.92                     |
| II   | New Delhi      | 449222              | 10084             | 744683.2                 | 387357                   | 47.98                     |
| III  | Jaipur         | 429851              | 9362              | 704157.6                 | 370641                   | 47.36                     |
| IV   | Luck now       | 434653              | 9326              | 707904.8                 | 387921                   | 45.20                     |
| V    | Gangtok        | 230844              | 35835             | 1280809.5                | 270405                   | 78.89                     |
| VI   | Thiruvananthapuram | 444419            | 3998              | 561560.4                 | 421733                   | 24.89                     |
From figure 2, it is clearly seen that the minimum energy required for hot water in Gangtok is in the month of September which is comparatively more than the maximum of any other city because here the temperature is low. Energy savings shown in table 2

Gangtok lies in the Himalayan range, where the temperature ranges from 22°C to 4°C. The winter season prevails over December to February, it requires more energy to keep the rooms warmer and provide comfort to the people residing. Hence the maximum energy required for space heat in Gangtok is in the months of January, December and gradually drops down which is clearly depicted in figure 3. Whereas in Chennai and Thiruvananthapuram the weather is almost hot so not much extra
energy is required to maintain the room temperature. Thus the curve is almost linear and close to the origin.

![Space Cooling](image)

**Figure 4.** Space Cooling.

Space cooling is opposite to space heat. New Delhi and Jaipur are located in the semi-arid and arid regions where the climate is mostly dry and hot it requires additional energy to maintain comfort zone especially in the peaks of summer, with no extra energy for cooling in the months of January and December (peak winter). Observing the figure 4, a similar curve is obtained in the case of Lucknow but since it does not experience extreme climatic conditions consequently the curve does not coincide with the origin.

![Estimated Monthly Energy](image)

**Figure 5.** Estimated Monthly Energy.
The estimated monthly energy varies drastically for Gangtok across the year (figure 5). In the month of January, Gangtok requires the highest energy when compared to other cities in India. The curve narrow downs in July where it almost coincides with all other cities except Thiruvananthapuram because the weather is almost good thus energy required is nominal. In December, Thiruvananthapuram and Gangtok requires almost equal amount of total energy because energy required for space heat in Gangtok is more due to low temperature, energy required for space cooling in Thiruvananthapuram is more due to high temperature. The data for the graphs are been collected from the GBS by generating an energy model in Revit and converting into gbXML file and importing it in the GBS.

4. Proposed climatic condition ratio

The climatic condition ratio derived (table 3) were determined using the monthly energy figures, taken in six different zones of India. The calculations are supported by figure estimated monthly energy (figure 5)

1. Calculate the difference between Total Energy (TE) and PV production (PV), which is named as (A).

\[ A = \text{TE} - \text{PV} \] ... (1)

\[ A = 607290.9 - 383031 = 224259.9 \] (Tropical wet and dry - Zone I)

2. Evaluate the percentage of energy saving for each zone/location.

\[ \text{Energy saving} = A \times \frac{100}{\text{TE}} \]

Energy saving = 224259.9 \times \frac{100}{607290.9} = 36.92\% \text{ (Tropical wet and dry - Zone I)}

Energy saving = 357626.2 \times \frac{100}{744483.2} = 47.98\% \text{ (Semi Arid - Zone II)}

Energy saving = 333516.6 \times \frac{100}{704157.6} = 47.36\% \text{ (Arid - Zone III)}

Energy saving = 319983.8 \times \frac{100}{707964.8} = 45.20\% \text{ (Humid Subtropical - Zone IV)}

Energy saving = 1010404.5 \times \frac{100}{1280809.5} = 78.89\% \text{ (Mountane - Zone V)}

Energy saving = 139827.4 \times \frac{100}{561560.4} = 24.89\% \text{ (Tropical wet - Zone VI)}
3. Determine the Zone Coefficient (ZC)

\[
ZC = \frac{\text{Energy saving in Zone I}}{\text{Energy saving in Zone II}}
\]

Tropical wet and dry climate versus Tropical wet and dry climate (Zone I)

\[
ZC = \frac{36.92}{36.92} = 1
\]

If the buildings are compared within the same climatic zone, the result will be equal to one as shown above. If the buildings are compared in different zones, the calculation is as follows:

Tropical wet and dry climate (Zone I) versus semi arid climate (Zone II)

\[
ZC = \frac{36.92}{47.98} = 0.7695
\]

The entire calculation for each zone to determine the climatic condition ratio is done by using the equation in table 3 (1).

| ZONE | I   | II  | III | IV  | V   | VI  |
|------|-----|-----|-----|-----|-----|-----|
| I    | 1.0000 | 0.7695 | 0.7796 | 0.8168 | 0.4680 | 1.4828 |
| II   | 1.2996 | 1.0000 | 0.0131 | 1.0615 | 0.6082 | 1.9270 |
| III  | 1.2828 | 0.9871 | 1.0000 | 1.0478 | 0.6003 | 1.9021 |
| IV   | 1.2243 | 0.9421 | 0.9544 | 1.0000 | 0.5729 | 1.8153 |
| V    | 2.1368 | 1.6442 | 1.6658 | 1.7454 | 1.0000 | 3.1684 |
| VI   | 0.6744 | 0.5189 | 0.5257 | 0.5509 | 0.5509 | 1.0000 |

5. Conclusion
The climatic condition ratio for various zones are been developed. Zone I represents Chennai which has Tropical wet and dry climatic conditions. Zone II has a semi-arid climatic condition and the test location was New Delhi. Jaipur was opted for arid conditions that fall under the category of Zone III. Lucknow depicts the Humid Subtropical condition for Zone IV. Zone V is the Mountane condition and the location chosen was Gangtok. Tropical wet condition exists in Southern zone and thus Thiruvananthapuram is selected for Zone VI.

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