Proceedings of IOE Graduate Conference, 2019-Summer
Peer Reviewed
Year: 2019 Month: May Volume: 6
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Energy Efficiency in Corporate Building through Envelop Improvement, A Case of Prabhu Bank Corporate Building in Kathmandu

Suresh Paudyal [a], Sushil Bahadur Bajracharya [b]

[a, b] *Department of Architecture &Urban Planning, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
Corresponding Email: [a] ar.sureshpaudyal@gmail.com

Abstract

Separating building from its surrounding environment by neglecting its ecological impact is the current unsustainable practice here in Nepal. Current energy demand deficit proves it, where demand is 1508.2 MW (Mega Watt) and production is 1073 MW [1], the shortfall amount is imported from neighboring country India, this data shows the energy dependency of the country. Among the various other sectors, taller towers of corporate buildings are the most energy consuming sector in the context of Kathmandu. The corporate building is the main office where the executives of the company including CEO have their office, it is also termed as headquarter building. Kathmandu being the capital, most corporate buildings are constructed here and more will be constructed in the near future. Developing the energy efficient corporate building with consideration of the micro climate of Kathmandu Valley, passive design strategies and with appropriate building envelop will lead to save significant amount of non-renewable energy consumption and less carbon emission to the surrounding environment. In this scenario this paper aims to explore the sustainable building envelop which will enhance the overall energy performance of the building. For this, Prabhu Bank Corporate building envelop was analyzed in existing scenario and alternate scenarios to get the best fit energy efficient design solution. Analysis is carried out through simulation modeling using ECOTECT software, bioclimatic chart and Climate Consultant software. Finally best fit building envelop is discussed and recommended in which up to 28.34% of energy consumption has been reduced.

Keywords

Energy Efficiency, corporate building, building envelop, simulation modeling

1. Introduction

Energy use in buildings worldwide currently account for about 32% of the global total final energy consumption. In terms of primary energy consumption, buildings represent around 40% in most countries and 65% of the total electric consumption[2].

Construction technology and material have been greatly influenced by the western material and technology from last few years here in Kathmandu Valley. Buildings are built without any consideration of local climate and its ecological foot prints. Vernacular materials which are time tested from long period of time are falling in less priority.

The Climate of Kathmandu Valley is generally cool and solar energy can be used to heat buildings, but contemporary Nepalese designers rarely address this concept. The Incorporation of solar energy in building design is one of the most important criteria for energy efficient building design in a climate like that of the Kathmandu Valley [3] .

Corporate sector is another neglected sector which consumes significant amount of energy in comparison to the other buildings, so making corporate building energy efficient and sustainable means contributing a lot to the environment.

Corporate is a term that pertains to corporations. A corporate office is the main office, also called the headquarters, of a corporation. This office is usually the hub of the company and often serves as the central location where top decisions are made. The corporate office is generally where the executives of the company, including the CEO, maintain their offices. A corporation might have other offices across the country or the world that report to the corporate office and the company's CEO. These additional offices might take their direction on company policy and practices from the decisions made at the corporate office[4].

Building envelop is the main part through which heat gain and heat loss occurs. Improving envelops with passive solar strategies, construction technology and materials reduces significant amount of energy consumption in corporate buildings which generally consists of large glass facades with normal glass thickness which becomes the main source of heat loss and gain. Researches has been showed that the average annual intensity of office building in western countries is 251.57 kWh/m^2 [5].

The purpose of this study is to minimize the energy demand of corporate buildings by passive strategies and envelop optimization. Energy consumption can be reduced significantly if envelop of a building is designed properly. The reduced energy use reduces operation cost and environmental impact.

The main objective is to study and analyze envelope of a building through simulation modeling using energy efficient alternative scenarios of a typical corporate building.

2. Methodology

The qualitative and quantitative both methods are used to carry out the research. Qualitative method is used for the interpretation of literature based on energy efficient parameters; whereas quantitative method is used for best fit energy efficient strategy and energy performance modeling of a corporate building.

The potential best-fit climate responsive design is explored through development of bio-climatic chart, Mahoney Table and Climate Consultant software. Finally, ECOTECT software is used to carry out the simulation modeling.

3. Literature Review

3.1 Energy Efficiency

According to Bajracharya (2014) Energy efficiency in building can be attained through three main factors:

1. Reduced heating, cooling demand
2. Utilize renewable energy sources
3. Increase efficiency of heating and cooling equipment

Among these three points, the first two can be achieved by proper envelop design. Building envelop plays a vital role in heat gain and loss. Using the renewable sources minimize the energy consumption significantly.

3.2 Corporate Buildings

The corporate headquarters (CHQ) is the central organizational unit in the contemporary corporation and is critical for value creation in the overall firm[6]. To gain the highest level of luxary for the executive officials, these types of buildings are more energy consuming. The energy econsumption in these energy extensive building can reduce significantly by consideration of the passive design strategies.

3.3 Building Envelop

It is the separator between the indoor and outdoor environment of a building which also acts as a barrier for heat, air, light, noise and water. A well-insulated building helps keeping the house cool during the summer and reduces heat loss during the winter.

It is critical to realize that improvement of the energy efficiency in the big scale buildings cannot be only by application of advanced mechanical systems and advanced technologies, but also by the design decisions that affect operation and management. These decisions have to be taken at the beginning of the building design process when its impact on energy efficiency would be most significant[7].

3.4 Simulation Modeling

Autodesk Ecotect Analysis is an environmental analysis tool which allows to simulate building performance from the beginning stages of design. It combines analysis functions with an interactive display that presents analytical results directly within the context of the building model.

Simulation in this research is mainly used for the calculation of the heat gain and heat loss in different alternative scenarios.

4. Case Study

Prabhu Bank corporate building is located at Babarmahal, West side of Dhobi Khola. The total site area is 2400 m^2 and plinth area is 1110 m^2. It consists of eight floor and total built up area is 8884.96 m^2.

The building is modern having glass façade in the East, ACP cladding in the East, North-East and South-East corner. Remaining other wall are normal 9” brick wall.

Figure 1: Front View of the Prabhu Bank

Internal partition is mostly 8 mm full height glass wall for cabins and low height aluminum partition for work stations.

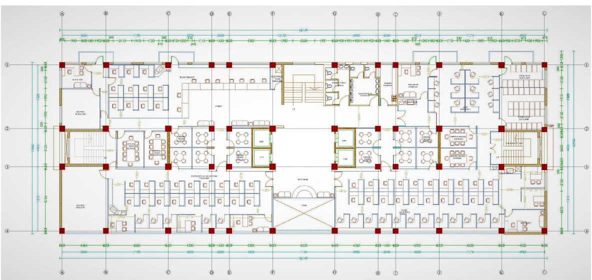

Figure 2: Typical Floor Plan of Prabhu Bank

Building is elongated towards North- South which is not good from the point of passive solar gain. In the south side same storey Sagarmatha Television building is situated at a distance of just 3 m which blocks all the south gain of the building.

5. Climatic Analysis

5.1 Temperature range of Kathmandu

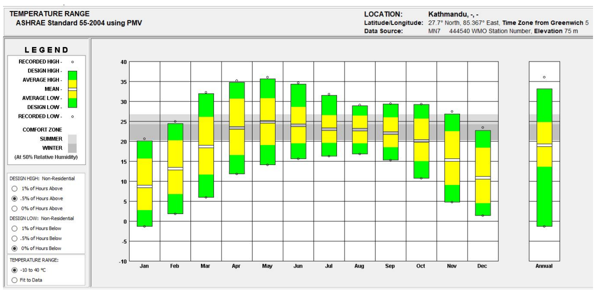

Figure 3: Temperature range of Kathmandu

Above Chart shows the temperature range of Kathmandu valley but the comfort range shown in ASHRAE standard from 20-26 °C is little bit different from our adaptive comfort range of 15-26 °C [8].

5.2 Bioclimatic chart

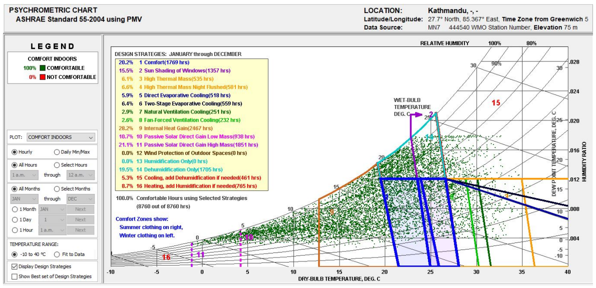

Figure 4: Bio-Climatic Chart of Kathmandu from Climate Consultant

Bioclimatic chart is produced by the analysis of 10 years period climatic parameters (Humidity and Temperature) from Department of Meteorology climatic data used here is from 2006 to 2016 AD. It shows the comfort range in between 18-26 °C. Five months November, December, January, February and March can be comfortable with passive solar heating while May, June and July needs air movement because they are hotter months.

6. Building Simulation

Building Simulation is carried out through Autodesk Ecotect Analysis 2011 software. Building simulation is carried out in three phases, as a base case, existing situation is simulated. Two more scenarios were created using different energy efficient material to analyze the energy consumption of the building.

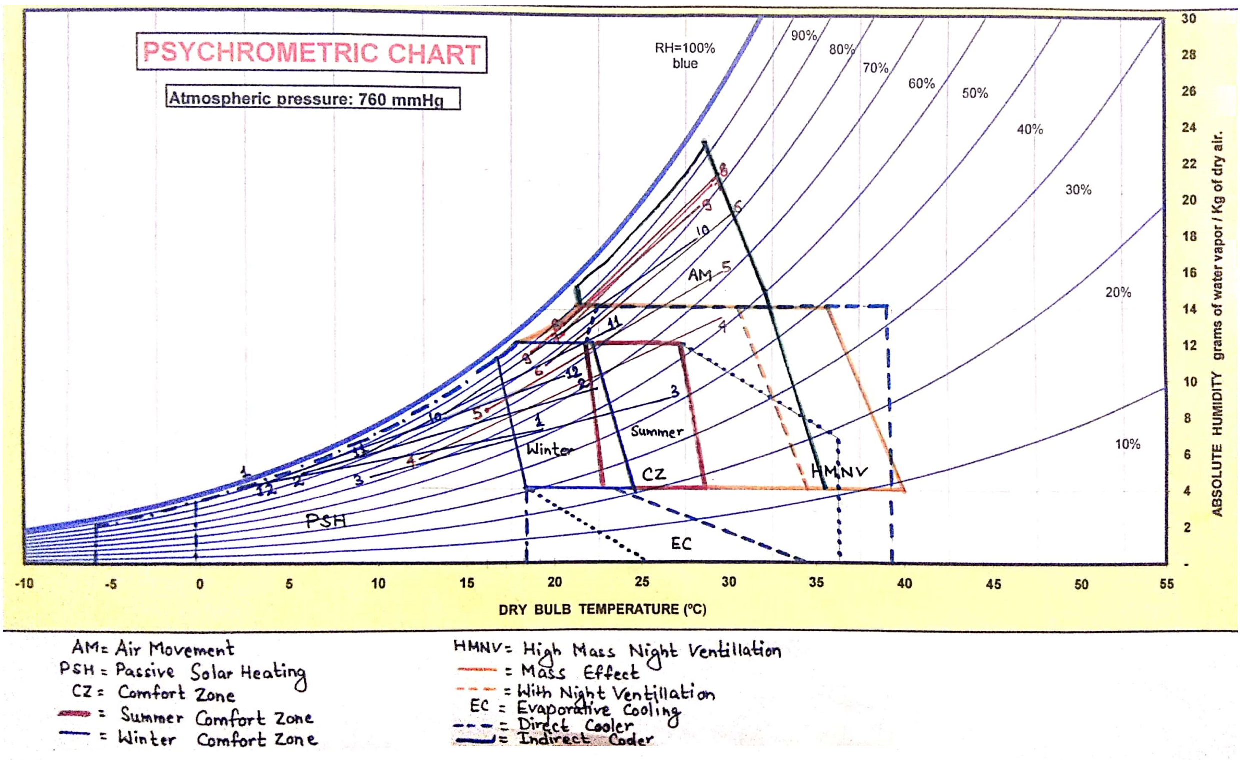

Figure 5: Bioclimatic chart of Kathmandu manually Drawn

Basically, thermal analysis is carried out in simulation modelling in which monthly heating/ cooling loads is calculated in all thermal zones. Climatic data of Kathmandu in Weather Data File format is used in the model. In internal design condition setting in thermal analysis, clothing level is considered as light business suit, humidity is considered 60%, air speed is 0.5 m/s which means pleasant breeze and lighting level is considered as 400 lux for office desk work. Similarly, AC system is considered Mixed Mode with 95% efficiency, thermostat range is taken as 16-26 ^{o}C and operation hours is 9am to 7 pm in week days and 10 am to 1pm in weekends according to the case study data.

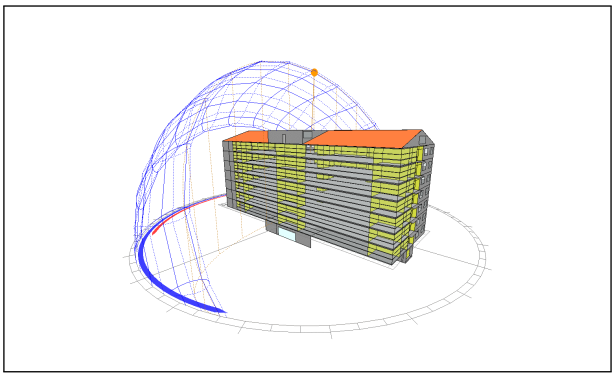

Figure 6: Building Simulation, Sun's Position on Summer Solstice, 21st June at 12 Noon

6.1 Base Case Scenario

Existing building scenario is considered as a base case. All the as built materials were added in the model. The base building consists of eight floors and occupancy of the whole building is 500 people in the week days as per the case study data. Eastern part of the building is fully glazed with ACP bands whereas other parts consist of aluminum windows.

Table 1: Material in the base case scenario

Building Envelop	Material
Outer Wall	230mm brick wall with both side plaster
NE and SW Wall band	6mm ACP cladding with 50mm air gap
Windows/Openings	6mm Single Glazed with Aluminum Frame
Flooring	Tile/Marble Finishing over Concrete
Roofing	CGI Roof with False Ceiling

Table 2: heating and cooling load of base case scenario

Zones	Heating load(kWh)	Cooling load(kWh)	Total load (kWh)
All	43124.476	86211.536	129336.016

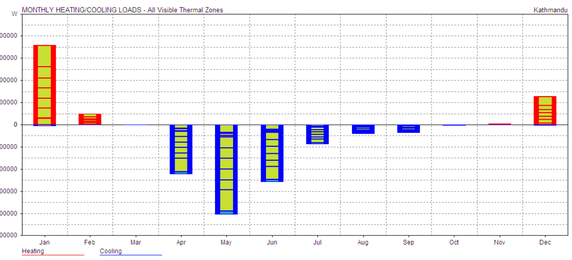

Figure 7: Monthly heating and cooling load of Base Case Scenerio

The result shows the cooling load is nearly twice the heating load. The over all load is 129336.016 kWh.

Mainly three months, Dec, Jan and Feb needs heating, major six months April to September needs Cooling. Per m^2 Heating Load is 5.1 kWh/m^2Annum and Cooling Load is 10.3 kWh/m^2Annum. Hottest Day is 21^{st} May when max cooling is needed and coldest month is12^{th}Jan when maximum heating is needed as per the result.

6.2 Alternative Scenario1

The consideration in this scenario is given as below:

Table 3: Envelop Material in the alternative scenario 1

Building Envelop	Material	U Value (W/m^2K)
Outer Wall	150mm outer and 100mm inner hollow concrete blocks cavity wall with 50mm cavity and 50 mm insulation in between with both side plaster	0.35
NE and SW Wall band	18mm Fiber Cement board with 50mm air cavity and 50 mm EPS Insulation in between	0.41
Windows Openings	8mm Double Glazed UPVC	1.6
Flooring	Terracotta Tile Over RCC Floor and Gypsum False Ceiling with 50 mm insulation and 600mm air gap	0.88
Roofing	UPVC Roof with 50mm insulation, 600mm air gap and Gypsum board false ceiling	0.47

In the alternate scenario 1, the aesthetic of the Corporate façade is taken care of, ACP is replaced with fiber cement board.

Brick wall is replaced with hollow concrete blocks with insulation because the embodied energy and U value is lower than that of brick. Insulation is provided in both Floor and ceiling.

Single glazed window is replaced into double glazed UPVC window with 8mm glass thickness.

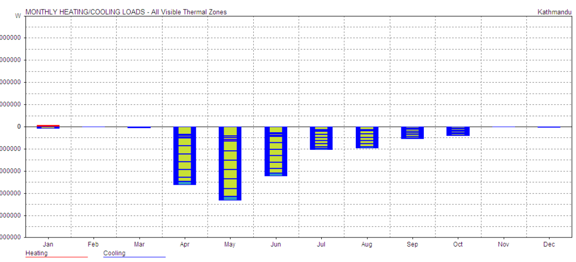

Figure 8: Monthly heating and cooling load of alternative scenario 1

Table 4: heating and cooling load of alternative scenario 1

Zones	Heating load(kWh)	Cooling load(kWh)	Total load (kWh)
All	700.476	92132.312	92832.792

Mainly four months needs heating in this scenario and other months needs Cooling. Per m^2 heating load is 0.084 kWh/m^2Annum and Cooling Load is 11.02 kWh/m^2Annum.Total Heating/Cooling load per sq m is 11.10 Kwh/m^2Annum

Over all heating/ cooling load is decreased by 28.22% in this scenario.

6.3 Alternative Scenario 2

The consideration in this scenario is given in table 5. In this scenario Hollow Concrete Blocks are replaced with Cellular Light Weight Concrete Blocks, double glazed UPVC windows are replaced with triple glazed UPVC windows and UPVC Roof is changed with sandwich panel roof of same material UPVC, other materials remains the same.

Table 5: Envelop Material in the alternative scenario 2

Building Envelop	Material	U Value (W/m²K)
Outer Wall	200mm Cellular Light Weight Concrete wall with 50mm cavity and 50 mm insulation in between with both side plaster	0.26
NE and SW Wall band	18mm Fiber Cement board with 50mm air cavity and 50 mm EPS Insulation in between	0.41, Same
Windows Openings	10 mm Triple Glazed UPVC	0.8
Flooring	Terracotta Tile Over RCC Floor and Gypsum False Ceiling with 50 mm insulation and 600mm air gap	0.88, Same
Roofing	UPVC EPS Sandwich Panel, 600mm air gap and Gypsum board false ceiling	0.42

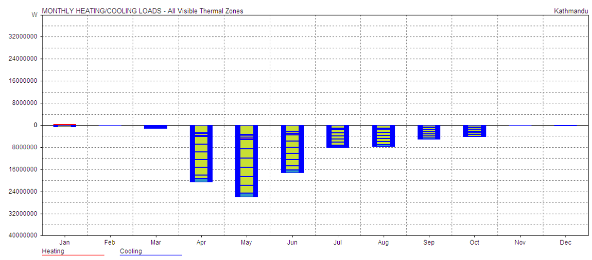

Figure 9: Monthly heating and cooling load of alternative scenario 2

Table 6: heating and cooling load of alternative scenario 2

Zones	Heating load(kWh)	Cooling load(kWh)	Total load (kWh)
All	327.023	92361.296	92688.320

In this alternative scenario 2 also, mainly four months need heating and other months need Cooling. Per m^2 heating load is 0.039 kWh/Annum and per m^2 cooling load is 11.04 kWh/Annum. Total Per m^2 Heating/Cooling Load is 11.08 kWh/Annum

Over all heating/ cooling load decreased by 28.34% than the base case scenario and only 0.12% than alternative scenario 1.

7. Finding Discussion

Table 7: Over all summary of final results

Scenario	Heating (kWh)/m²	Cooling (kWh)/m²	Total (kWh)/m²	Eff.%
Base Case	5.159	10.313	15.471	
Alternate Scenario 1	0.084	11.021	11.105	28.22%
Alternate Scenario 2	0.039	11.048	11.087	28.34%

Result shows that 28.22% of energy consumption can be reduced if the building envelop is considered while designing in alternative scenario 1 and 28.33% of energy consumption is reduced in alternative scenario 2. No significant dropped is observed in scenario 2, result shows, triple glazing window does not play significant role in the climate of Kathmandu.

By incorporating all the parameters the energy saving potential ranges would be as high as ranging from 17 to 42% [9]. The research in building envelop for energy efficiency in office building in India also validates the finding of this research.

8. Conclusion

It is concluded that significant amount of energy can be reduced by simply altering the building envelop in the acceptable level by considering aesthetics of corporate building, it is found that up to 28.34% of energy consumption can been reduced.

Cooling Load is not dropped; it shows that building needs shading devices to reduce the summer heat gain of the building.

Similarly, climate of Kathmandu is relatively cool so passive solar heat gain is very significant to maintain the comfort level which is cleared from bioclimatic chart and climate consultant results.

References

[1] M. o. F Government of Nepal. Economic survey, 2074/075, kathmandu: s.n. Technical report, 2018.

[2] IEA. World energy outlook. Technical report, 2010.

[3] Anir Kumar Upadhyay, Harunori Yoshida, and Hom Bahadur Rijal. Climate responsive building design in the kathmandu valley. *Journal of Asian Architecture and Building Engineering*, 5(1):169–176, 2006.

[4] smallbusiness.chron.com. Technical report, 2018.

[5] U.S Environmental Protection Agency. Clean energy, sector collaborative on energy efficiency accomplishments and next steps, a resource of the national action plan for the energy efficiency. Technical report, 2008.

[6] Markus Menz, Sven Kunisch, and David J Collis. The corporate headquarters in the contemporary corporation: Advancing a multimarket firm perspective. *The Academy of Management Annals*, 9(1):633–714, 2015.

[7] Hatice Sozer. Improving energy efficiency through the design of the building envelope. *Building and environment*, 45(12):2581–2593, 2010.

[8] HB Rijal, H Yoshida, and N Umemiya. Seasonal and regional differences in neutral temperatures in nepalese traditional vernacular houses. *Building and Environment*, 45(12):2743–2753, 2010.

[9] Farheen Bano and Mohammad Arif Kamal. Examining the role of building envelope for energy efficiency in office buildings in india. *Architecture Research*, 6(5):107–115, 2016.