KEC Conference 2026

ISSN: 3021-940X (Print) DOI: 10.3126/injet.v3i2.95658

Energy Optimization of Building in Revit with Passive Design Strategies for Kathmandu, Nepal

Aishra Krish Rai[1*]

[1]*Department of Civil Engineering, Kantipur Engineering College, Dhapakhel, Lalitpur, Nepal,* iceshraa@gmail.com

---

Abstract

The building sector is a major contributor to global energy consumption. Innovations aimed at reducing energy use in this sector can significantly advance the achievement of Sustainable Development Goals. Climate-responsive buildings leverage natural climatic elements, such as air temperature, relative humidity, wind, solar irradiation, and rainfall to minimize energy demand for heating, cooling, and lighting. This study optimized building strategies for the warm-temperate climate of Kathmandu, Nepal, using Autodesk Revit. The result obtained from building energy simulation of the baseline and passive building showed significant reduction in Energy Use Intensity and Heating, Cooling, Lighting and Equipment load. The building optimized with passive design strategies consumed 21% less energy and performed 22% better in total site energy reduction and Energy Use Intensity Reduction compared to the normal building, demonstrating the effectiveness of climate-adaptive design in reducing operational energy demand. These findings contribute to the achievement of SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action).

Keywords: Climate Responsive Building, Energy Consumption, Revit BIM-BES

---

1. Introduction

Globally, the building industry accounts for approximately 30 to 31% of final energy consumption (International Energy Agency, 2026) [1]. In Nepal, the residential building sector alone contributes 60.75% of the nation's total energy consumption (Government of Nepal, Water and Energy Commission Secretariat, 2024) [2]. Over the years, multiple approaches to energy-efficient building design, such as active buildings, passive houses, green buildings, net-zero buildings, and climate-responsive buildings have emerged. Correspondingly, software tools like EnergyPlus, Ladybug, DesignPH, and Green Building Studio have emerged for building energy optimization.

Autodesk Revit, a Building Information Modeling (BIM) software, provides an inbuilt energy analysis tool through OpenStudio. This software enables the design of building models with smooth conversion into building energy models, performs comprehensive energy simulations, and generates detailed outputs of energy consumption for heating, cooling, lighting, and equipment, monthly electricity usage, district heating and cooling consumption, peak demand, and energy metrics per total and conditioned building area [3]. Such data aids in the planning and design of energy-efficient buildings and, in the best-case scenario, support the achievement of net-zero energy buildings [4]. However, the reliability and efficacy of the results produced by this inbuilt operator require careful assessment.

Nepal has five main climatic zones, with the Kathmandu Valley predominantly falling under the warm-temperate climate, ranging from 1,200 m to 2,100 m above sea level [5]. Each climatic zone requires unique building design strategies to adapt effectively, and several research studies have proposed passive design strategies using bioclimatic charts specific to Nepal's climate [6] [7]. Despite this, most modern residential constructions in Nepal neglect environmental and climatic considerations, resulting in higher carbon footprints and increased energy consumption [8].

Buildings that do not adapt to the local climate require additional energy to maintain occupant comfort. This research aims to reduce building energy consumption in Kathmandu through the integration of passive design strategies using Revit software. Additionally, it seeks to validate the passive design strategies recommended

---

[*] *Corresponding author*

by architects using bioclimatic charts, demonstrating their effectiveness through building energy optimization software.

2. Literature Review

2.1 Climate Responsive and Passive Design Strategies

2.1.1 Guidelines and Design Manual:

Manual for Energy Efficient Building Design (Second Edition, 2026) by Switch Asia BEEN project suggests passive building envelope strategies for different climatic zones of Nepal. For warm temperate zone, it recommends exterior wall assembly of 10mm internal plaster+ 240mm thick hollow brick wall + 10mm external plaster, roof assembly of 10mm internal plaster + RCC slab 125mm thick + 25mm XPS insulation+50mm screed and tile (U-value 0.8 W/m2 K), window assembly of double glazed unit (SHGC: 0.54, U value 2.8 W/m2 K, VLT 58%) with wooden frame, Window to wall area ratio(WWR) 25% overall, higher distribution on north facade, followed by south facade, casement windows and continuous overhang shading of 600mm+EMSyS on south, west and east facing windows. [9]

2.1.2 Research Paper:

Lamsal et al. (2021) presented guidelines for climate-responsive building design across three climatic regions of Nepal. For temperate climates, the study recommends the incorporation of passive heating and cooling strategies, the use of deciduous vegetation on eastern and western facades, and provision of spacing for natural ventilation while protecting against extreme winds. The study further suggests single-banked room configurations, window-to-wall ratios of 25 to 40% on the southern facade with cross ventilation, and the use of high thermal mass materials in walls and roofs combined with light, smooth interior finishes and wooden flooring [7].

Lamsal et al. (2016) suggested passive solar building strategies for cities including Lalitpur, Pokhara, and Dharan. For Lalitpur, the study recommends compact planning, incorporation of deciduous trees on eastern and western sides, and elongated rectangular building forms promoting diagonal cross ventilation. The study further suggests maintaining window openings between 20 to 40% of floor area and providing minimum shading projections of 2ft 9in to avoid direct sunlight [10].

Bodach et al. (2016) provided design guidelines for energy-efficient hotels in Nepal which recommends larger south-facing windows with a window-to-wall ratio of approximately 40% for regions above 1000 m elevation to enhance passive solar heating. Additionally, high thermal mass is recommended for elevations above 500 m, while ground floor insulation of 50–100 mm thickness is suggested for elevations exceeding 1500 m. The study concludes that buildings optimized with passive design strategies can achieve an average energy reduction of approximately 37% compared to conventional designs [11].

A.K. et al. (2006) suggested climate-responsive building design in the Kathmandu Valley using bioclimatic charts and Mahoney tables. The study recommends orienting the building along the east–west axis, incorporating open spaces for ventilation ensuring protection from hot and cold winds. It further suggests single-banked room layouts with permanent air movement provisions, window openings ranging between 25–40%, and positioning of openings on the windward side. Southern openings are identified as effective for solar heat gain and day lighting, whereas northern openings are recommended to be minimized [6].

2.2 Energy Simulation and Analysis through Revit:

Gupta et al. (2024) conducted building energy performance modeling of a hotel using Autodesk Revit. The study demonstrates that Revit can be effectively used to estimate cooling loads and predict annual energy consumption. It also provides insights into peak heating and cooling demand, electrical loads for lighting, and appliance usage, thereby supporting early-stage design decision-making [12].

Malik et al. (2022) analyzed an energy-sustainable residential building and validated its performance using Autodesk Revit. The study found that minor modifications in design strategies can result in significant variations in building energy consumption, highlighting the sensitivity of energy performance to design parameters [13].

Mogli et al. (2022) evaluated energy consumption of residential buildings using Autodesk Revit and the Insight plugin. The study considers multiple parametric variables, including building orientation, daylight controls, infiltration rates, HVAC systems, lighting efficiency, and envelope characteristics. The findings indicate that Revit enables comparative analysis of different design alternatives, facilitating the selection of cost-effective and energy-efficient solutions prior to construction [3].

Chuah et al. (2019) performed building energy analysis of a school using Revit. The study demonstrates the capability of the software to predict annual energy performance, including CO_2 emissions, electrical consumption, and seasonal heating and cooling loads [14].

3. Statement of Problem

- Modern residential buildings in Nepal are constructed without consideration for climatic factors.
- Large amount of energy is consumed in the Heating, Cooling and Lighting of the buildings which could have been saved to a certain extent provided that building were constructed incorporating passive design strategies [15]
- Research Papers verifying the efficacy of suggested passive design strategies through building modelling are limited

4. Research Objectives

- To optimize energy consumption in building using Passive Design Strategies
- To verify the design strategies suggested by various researches of Nepal through building modelling
- To assess the efficacy of Revit’s inbuilt Energy Optimization tool

5. Methodology

Literature review of the recommended passive design strategies for different climatic zones in Nepal was done and papers mentioning the use of Autodesk Revit for energy simulation were assessed. Then after, the floor plan and elevation of the building was drawn in AutoCAD, followed by Building Information Modelling in Autodesk Revit. The initial building model, termed Baseline Building is then modified two times; for wall modification, and then for combined wall-window modification with the placement and sizes of windows to achieve Window-to-Wall Ratio of 25%. The precise location of building was set as 27.767 latitude and 85.37 longitude in Revit and weather stations are allocated by Revit itself around the project location. Energy models were created for each building model to analyze the energy consumption. The final results were drawn comparing the simulation results against one another.

5.1 Building models

Model 1 (Baseline building) has 230mm thick brick wall, with sliding double window with thermal properties defined by schematic type. The window to wall ratio (WWR) is kept 37%. Five-storey residential apartment building with 1181.4 m2 total building area.

Model 2 (Building with wall modification) has 240 mm brick wall with 10 mm cement plaster each as internal and external finish. The heat transfer coefficient (U-value) of 1.6 $W/(m^2 \cdot K)$ for the wall assembly was adopted in accordance with the recommendations of the Manual for Energy-Efficient Building Design published by the SWITCH-Asia BEEN Project [9]. The remaining is same as that of baseline building.

Model 3 (Building with combined modifications and changes in window sizes and placement): 25% Window to Wall Ratio, Window openings in North elevation kept negligible, larger windows kept in East Elevation, cross ventilation provided, 240 mm brick wall with 10 mm cement plaster each in internal and external finish, with heat transfer coefficient (U) value of wall kept 1.6 W/(m2.K), and window with Solar Heat Gain Coefficient SHGC 0.54, Heat Transfer Coefficient U-Value 2.8 W/(m2.K) and VLT 58% with wooden frame.

The WWR of 25% adopted in Model 3 was selected on the basis of recommendations from Nepal-specific literature and design guidelines. The Manual for Energy Efficient Building Design (Switch Asia, 2026) [9], used as a primary reference for passive design strategies in Nepal's warm temperate zone, explicitly recommends an overall WWR of 25%. This is further supported by Lamsal et al. (2021) and A.K. et al. (2006), who suggest WWR values in the range of 25–40% for temperate climates of Nepal with cross ventilation provision [7][6]. Since the baseline building had a WWR of 36.99%, which exceeds the recommended range for energy-efficient design, it was reduced to 25% in Model 3 to align with the literature-recommended optimum for the given climatic zone.

6. Scope and Limitation

While Revit's inbuilt tool serves as a good product in showcasing the energy consumption results obtained by implementing various design strategies, the amount by which energy can be saved depends upon the skill of the designer as the software does not suggest strategies. Furthermore, the analysis such as shading, roof insulation and floor insulation were not performed and Window to Wall Ratio was also manually calculated. The suggestion of vegetation planting; deciduous trees in East and West direction and its impact is not considered while doing this research. Actual energy consumption data from a constructed building was not used for direct comparison as construction and monitoring of building were outside the scope of this study and results were validated indirectly through the preexisting literature work.

7. Results and Outcome

Figure 1. Baseline building

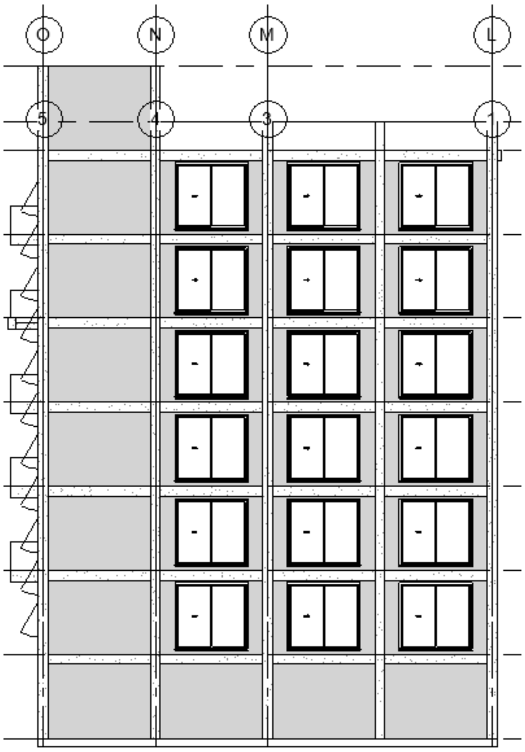


Figure 1.1 East Elevation

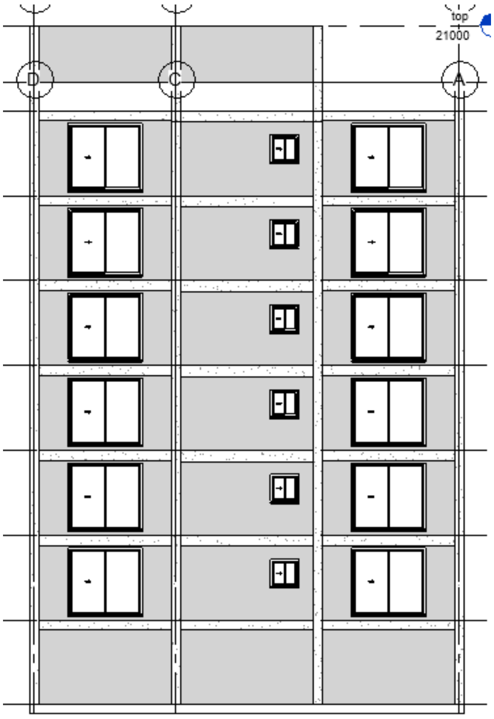


Figure 1.2 North Elevation

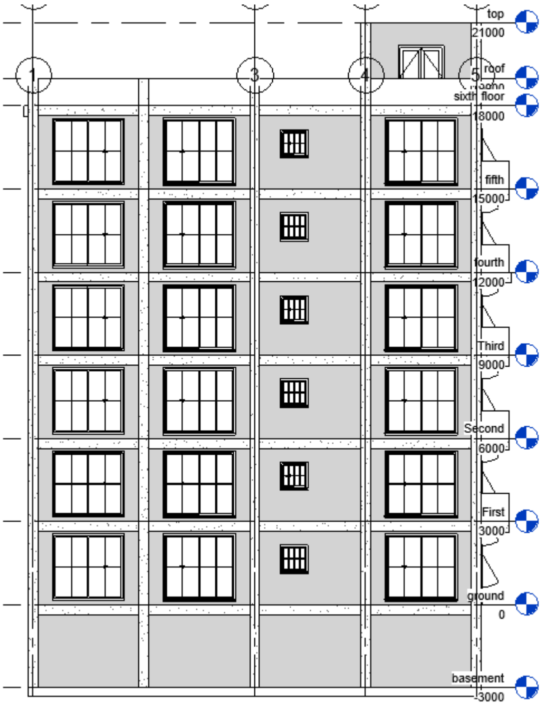


Figure1.3 West Elevation

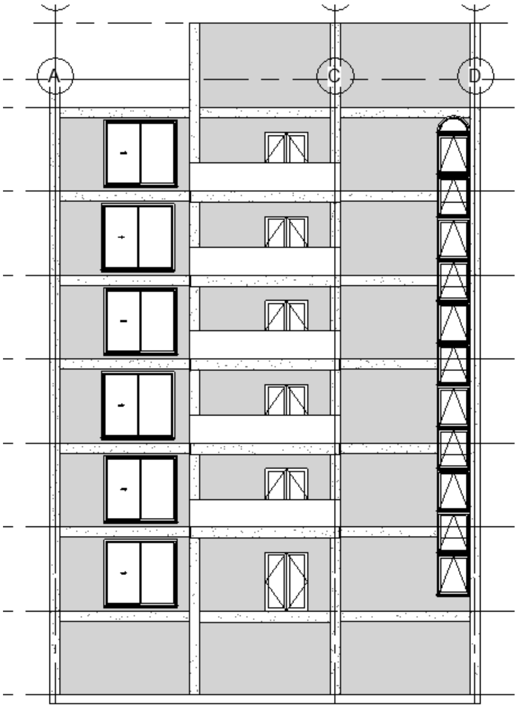
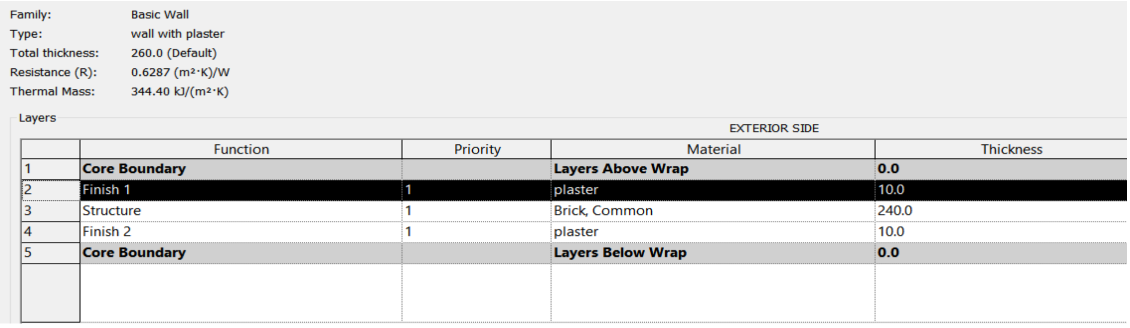


Figure 1.4 South Elevation



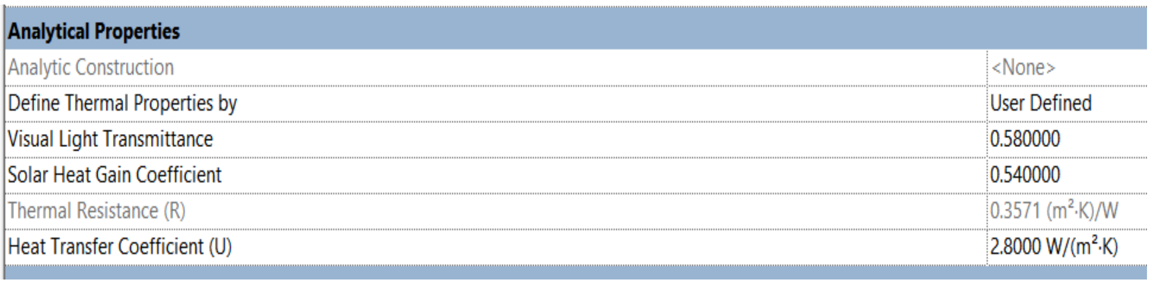
Family: Basic Wall
Type: wall with plaster
Total thickness: 260.0 (Default)
Resistance (R): 0.6287 (m²·K)/W
Thermal Mass: 344.40 kJ/(m²·K)

Layers

EXTERIOR SIDE

	Function	Priority	Material	Thickness
1	**Core Boundary**		**Layers Above Wrap**	**0.0**
2	Finish 1	1	plaster	10.0
3	Structure	1	Brick, Common	240.0
4	Finish 2	1	plaster	10.0
5	**Core Boundary**		**Layers Below Wrap**	**0.0**

Figure 2. Brick wall 240mm with internal and external insulation of 10 mm each for model 2 and model 3



Analytical Properties	
Analytic Construction	<None>
Define Thermal Properties by	User Defined
Visual Light Transmittance	0.580000
Solar Heat Gain Coefficient	0.540000
Thermal Resistance (R)	0.3571 (m²·K)/W
Heat Transfer Coefficient (U)	2.8000 W/(m²·K)

Figure 3. User defined window properties for model 2 and model 3

7.1 Window distribution per floor

Window 1 (W1) = 2.5m*2.3m
Window 2 (W2) = 0.9m *0.9m
Window 3 (W3) = 1.8m *2m
Window 4 (W4) = 1.085m*1.385m

Table 1. Description of window distribution

Building model	**Elevation**				**Total Window area (m^2)**
	North	West	South	East	
Baseline building	2nos* W1 + 1nos*W2	1nos* W2+ 3nos*W1	1 and half nos *W4 + 1nos *W1	3nos * W1	55.624
Model 3	1nos * W2	1nos*W2 + 3nos W3	1 and half nos *W4 + 1nos *W1	3nos * W1	37.674

Table 2. Window to Wall Ratio (WWR):

Building Model	**Area per floor (m^2)**		**WWR (%)**
	Wall	**Window**	
Baseline Building	150.374	55.624	36.99
Model 2	150.374	55.624	36.99
Model 3	150.374	37.674	25.05

7.2 Monthly Overview

7.2.1 District Cooling Consumption:

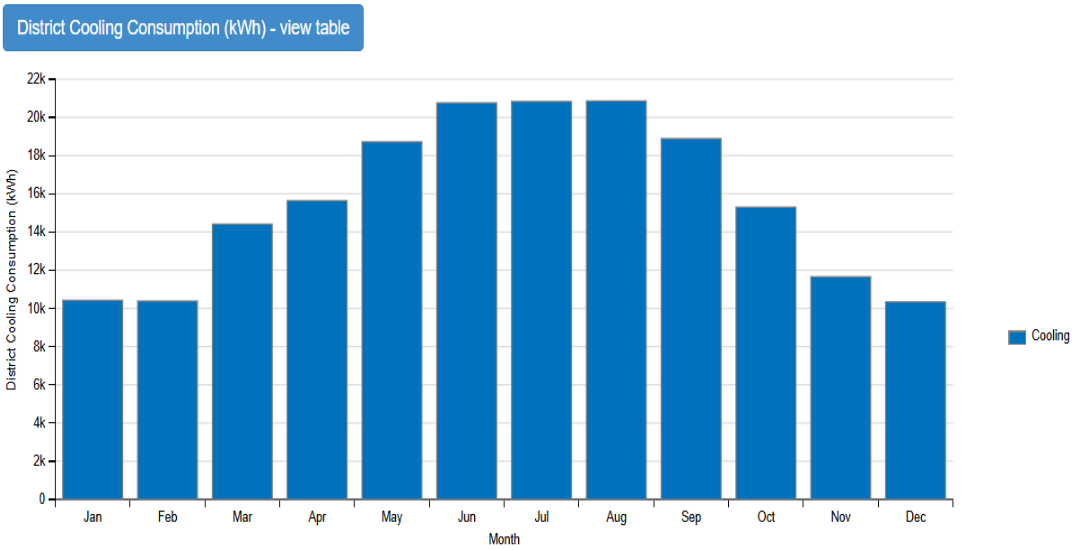
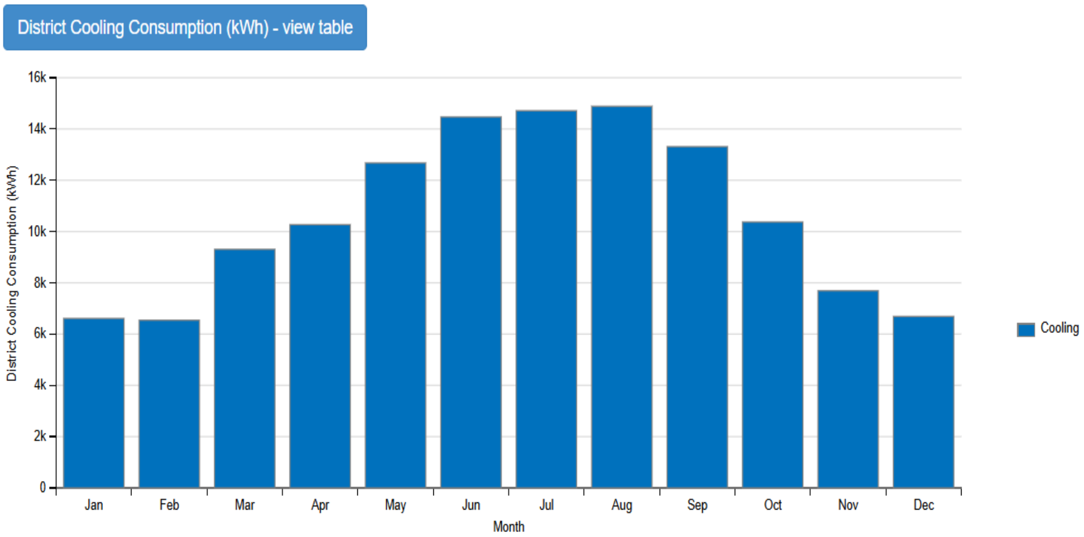


Figure 4. District cooling consumption of baseline building



Figire 5. District cooling consumption of Model 3

7.2.2 District Heating Water Consumption

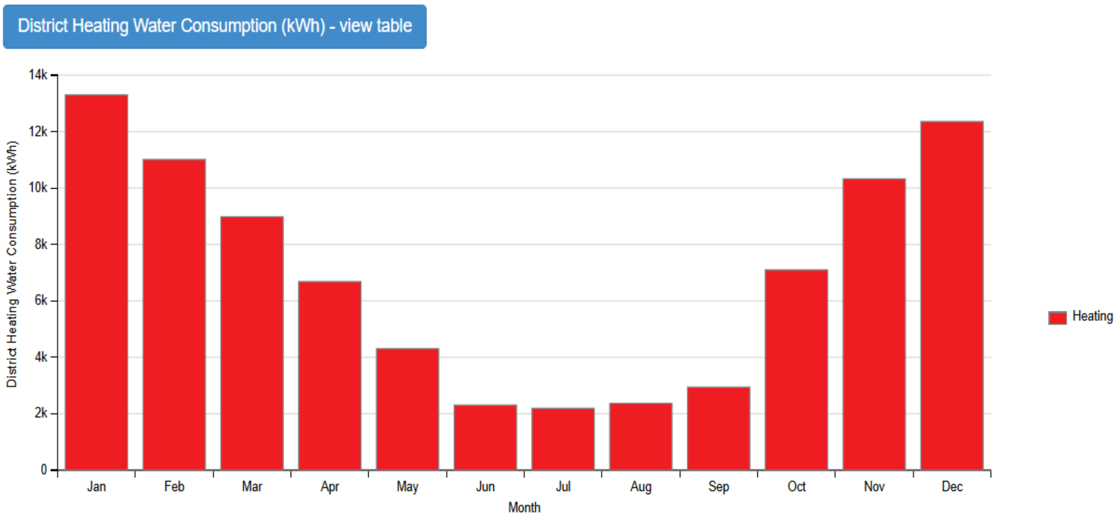


Figure 6. District heating water consumption of baseline

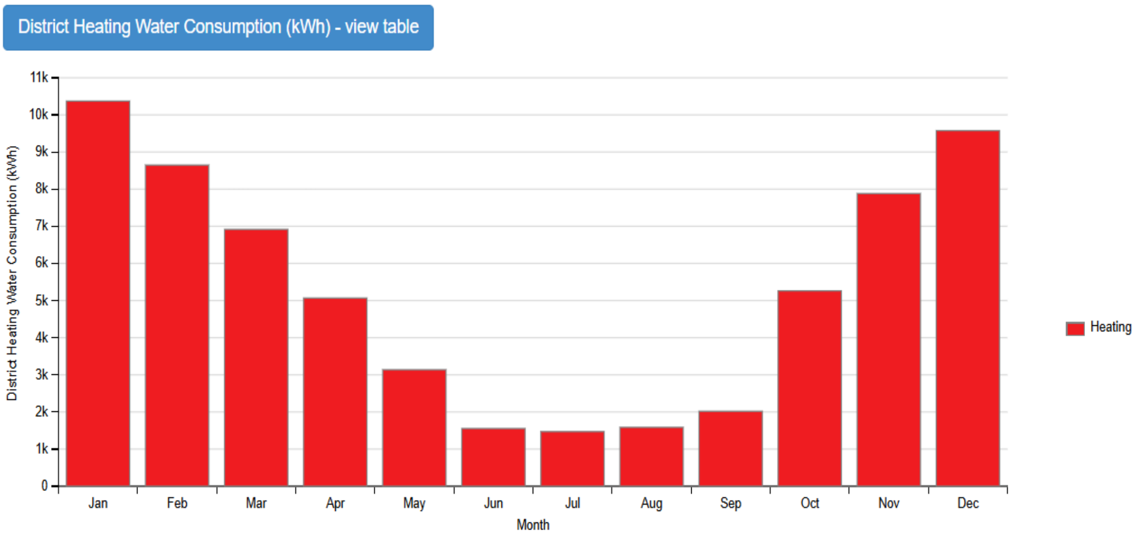


Figure 7. District heating water consumption of Model 3

7.3 Annual Overview

Table 3. End Use

End Use	**Consumption(kWh)**		
	Model 1 Baseline Building	Model 2 (wall modification)	Model 3 (combined window and wall modification)
Heating	83853	82872	64158
Cooling	188236	184053	131044
Interior Lighting	44172	43144	43144
Interior Equipment	57425	56089	56089

Total Energy Consumption:
Baseline Building (Model 1) = 373686 kWh
Model 2 = 366158 kWh
Model 3 = 294435 kWh

Table 4. Reduction in Energy Consumption in comparison with Baseline building

Building	**Overall (%)**	**Heating (%)**	**Cooling (%)**	**Lighting (%)**	**Equipment (%)**
Model 2	2.015	1.17	2.222	2.385	2.327
Model 3	21.208	23.488	30.383	2.383	2.327

The passively designed building demonstrates a significant reduction in energy demand, particularly in the heating and cooling load, which decreased by approximately 24% and 30 % respectively.
Lighting and equipment load is reduced by 2%.

Table 5. Site Energy

Building	**Total Energy (GJ)**	**Energy per total building area (MJ/m^2)**
Baseline Building	1345.27	1138.71
Model 3	1044.82	887.51

Total site energy reduction in model 3 (passively designed building) = 22.33%
Energy intensity reduction in model 3 = 22.06%

Total site energy demand decreased by approximately 22%, indicating improved thermal performance and reduced dependency on mechanical systems [16]. The Energy Use Intensity (EUI) shows a reduction of about 22%, which confirms that the passive strategies have effectively enhanced building efficiency [17].

8. Discussion

This study highlights the potential of passive design strategies to contribute in the achievement of Sustainable Development Goals by quantifying the positive outcomes of constructing climate-responsive building design. The findings can provide valuable guidance for engineers, architects, planners, and researchers in optimizing building performance prior to construction. Autodesk Revit proved to be a useful tool for simulating and analyzing building energy use, where design adjustments can be made easily to achieve desired performance outcomes. It also facilitates, smooth conversion from Building Information Modelling to Building Energy Simulation.

While significant improvements were observed in heating and cooling demand, the similar level of reduction for interior lighting and equipment loads was not achieved. Moreover, the changes in energy consumption from modifying window material properties resulted in only marginal energy savings, which shows the limitation of this inbuilt tool. Window-to-Wall Ratio had to be calculated manually and there was no provision for shading analysis. Hence, for a more detailed analysis, the plugin for Revit, Insight Green Building Studio (GBS) is recommended. However, significant changes could be observed while changing the placement of windows and decreasing the Window to Wall Ratio to 25%.

8.1 Validation of Results

The results obtained in this study were generated using Autodesk Revit's built-in energy analysis tool, which utilizes simulation engines based on Energy Plus [18], the US Department of Energy's Open Source building energy modelling software [19]. EnergyPlus has been extensively validated using ASHRAE standard 140 BESTEST, a widely accepted benchmark for evaluating building energy simulation programs. [20] This establishes the credibility of the simulation engine used and hence the reliability of the results obtained in the study.

Since actual energy consumption data from a constructed building was not used for direct comparison as construction and monitoring of building were outside the scope of this study, the results were validated through indirect methods which involve comparing the trend and magnitude of energy reduction with findings from previously published similar studies conducted in Nepal with comparable climatic condition.

Bodach et al. (2016), in their study of energy-efficient building design across the bioclimatic zones of Nepal, found that building optimized with passive design strategies achieved an energy reduction of approximately 37% compared to conventional designs [11]. The 21% overall energy reduction observed in Model 3 of this study falls within an expected and reasonable range as only envelope modifications (specifically wall assembly and window-to-wall ratio) were implemented, while strategies such as roof insulation, floor insulation and shading devices were excluded from the scope of this study.

Similarly, Lamsal et al. (2016) and Lamsal et al. (2021) cofirmed that passive strategies such as optimized WWR, wall thermal mass and cross ventilation yield measurable reductions in heating and cooling loads in Nepal's temperate zone [10][7], which is consistent with the findings of this study.

These comparisons with Nepal-specific literature support the validity of the simulation results and indicate that the obtained energy savings are consistent with the expected performance for the buildings under similar climatic and design conditions.

9. Conclusion

Revit is used for Building Information Modeling and general building energy analysis comparison. It can be concluded that designs that are optimized by passive strategies have the potential to consume less energy than designs that do not consider these strategies.

Designing buildings in accordance with local climatic conditions not only reduces energy consumption but also enhances occupant comfort. In the context of a Least Developed Country like Nepal, it is increasingly important for the construction industry to adopt climate-responsive and energy-efficient building practices to reduce operational energy demand, mitigate carbon emissions, and improve overall quality of life.

Acknowledgement

I would like to express my sincerest gratitude to my tutor, Er. Sopan Gochhe, for his guidance in building energy simulation and incorporating passive design strategies in Autodesk Revit, which formed the foundation of this research. I am also thankful to Er. Kirti Dhungana, Er. Sahadeep Thapa, and Er. Abhinesh Khatri for believing in me. I owe my heartfelt appreciation to my parents for making my academic journey possible. Finally, I am deeply grateful to Dipak Shrestha, whose encouragement and support kept me going throughout this research.

References

[1] International Energy Agency. (2026). *Electricity 2026*. https://www.iea.org/reports/electricity-2026

[2] Government of Nepal, Water and Energy Commission Secretariat. (2024). *Energy sector synopsis report 2024 (FY 2079/80)*. https://giwmscdnone.gov.np/media/pdf_upload/Energy%20Sector%20Synopsis%20Report%20(2024%20FY%202079-80)_qbbivka.pdf

[3] S. S. Mogili, C. S. Sreekar, B. Sai Deepika, and M. V. Seshagirirao, "Energy consumption analysis of residential building using Autodesk Revit," *IOP Conference Series: Earth and Environmental Science*, vol. 1086, no. 1, p. 012056, Sep. 2022. [Online]. Available: https://www.researchgate.net/publication/364575701

[4] S. Habibi, "Role of BIM and energy simulation tools in designing zero-net energy homes," *Construction Innovation*, vol. 22, no. 1, pp. 1–25, May 2021. [Online]. Available: https://www.emerald.com/insight/content/doi/10.1108/ci-12-2019-0143/full/html

[5] S. Bodach, W. Lang, and J. Hamhaber, "Climate responsive building design strategies of vernacular architecture in Nepal," *Energy and Buildings*, vol. 81, pp. 227–242, Oct. 2014. doi: 10.1016/j.enbuild.2014.06.016

[6] A. K. Upadhyay, H. Yoshida, and H. B. Rijal, "Climate responsive building design in the Kathmandu Valley," *Journal of Asian Architecture and Building Engineering*, vol. 5, no. 1, pp. 169–176, May 2006. [Online]. Available: https://www.researchgate.net/publication/239416226

[7] B. Lamsal, S. Phuyal, and S. Tamrakar, "Guidelines for climate responsive building design in three regions of Nepal," *Journal of Building and Environmental Engineering*, vol. 2, no. 1, pp. 63–74, 2021. [Online]. Available: https://www.researchgate.net/publication/351090337

[8] European Commission, "Building Energy Efficiency in Nepal (BEEN)," *International Partnerships, European Commission*, 2023. [Online]. Available: https://international-partnerships.ec.europa.eu/policies/programming/projects/building-energy-efficiency-nepal-been_en

[9] SWITCH-Asia BEEN Project, *Manual for Energy-Efficient Building Design*, 2nd ed. Innsbruck, Austria: University of Innsbruck (UIBK) / MinErgy Pvt Ltd, 2026. [Online]. Available: https://www.switch-asia.eu/resource/manual-for-energy-efficient-building-design/.

[10] P. Lamsal and S. B. Bajracharya, "Passive solar building design strategies in Lalitpur, Pokhara and Dharan cities of Nepal," in *Proc. IOE Graduate Conference*, vol. 4, Lalitpur, Nepal, 2016, pp. 1–8. ISSN: 2350-8914 (Online), 2350-8906 (Print). [Online]. Available: http://conference.ioe.edu.np/publications/ioegc2016/IOEGC-2016-46.pdf

[11] S. Bodach, W. Lang, and T. Auer, "Design guidelines for energy-efficient hotels in Nepal," *International Journal of Sustainable Built Environment*, vol. 5, no. 2, pp. 411–434, Jun. 2016. doi: 10.1016/j.ijsbe.2016.05.008

[12] L. Gupta and R. Sharma, "Building energy performance modeling and simulation of hotel building," *Proceedings on Engineering Sciences*, vol. 6, pp. 1497–1508, Dec. 2024. doi: 10.24874/PES06.04.009.

[13] A. Malik, R. Kumar, R. Gupta, V. Vikal, Minhan, and U. Bhardwaj, "Building energy performance modeling and simulation of hotel building," *Journal of Physics: Conference Series*, vol. 2178, p. 012025, 2022. doi: 10.1088/1742-6596/2178/1/012025

[14] K. H. Chuah and A. W. Muhammad Alwi, "Building energy analysis of a school building using Revit," *INTI Journal*, vol. 2020, no. 31, 2020. ISSN: 2600-7320. [Online]. Available: http://eprints.intimal.edu.my/1446/

[15]. O. Iwuanyanwu, A. C. Okwandu, and C. S. Ike, "The role of passive design strategies in enhancing energy efficiency in green buildings," *Engineering Science and Technology Journal*, vol. 3, no. 2, pp. 1–15, 2022. doi: 10.51594/estj.v3i2.1519

[16] NetZeroCities, "Passive building design strategies: Building orientation, passive heating and cooling," *NetZeroCities Knowledge Hub*, 2023. [Online]. Available: https://netzerocities.app/resource-194

[17] TestFit, "Why developers need to consider energy use," *TestFit Blog*, 2023. [Online]. Available: https://www.testfit.io/blog/why-developers-need-to-consider-energy-use

[18] U.S. Department of Energy, "Autodesk brings detailed EnergyPlus HVAC simulation to Revit," *U.S. Department of Energy, Buildings*, Sep. 2019. [Online]. Available: https://www.energy.gov/cmei/buildings/articles/autodesk-brings-detailed-energyplus-hvac-simulation-revit

[19] U.S. Department of Energy, "EnergyPlus," *U.S. Department of Energy, Buildings*, 2024. [Online]. Available: https://www.energy.gov/cmei/buildings/articles/energyplus

[20] R. H. Henninger and M. J. Witte, "EnergyPlus testing with ANSI/ASHRAE Standard 140-2001 (BESTEST)," Lawrence Berkeley National Laboratory, Berkeley, CA, USA, Tech. Rep., 2004. [Online]. Available: https://simulationresearch.lbl.gov/dirpubs/epl_bestest_ash.pdf