Proceedings of 10th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2021 Month: October Volume: 10

Parameters Influencing the Adoption of Energy Efficiency in the Building Design Process

Upashana Poudel [a], Sanjay Uprety [b], Barsha Shrestha [c]

[a, b, c] *Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
Corresponding Email: [a] upashna32@gmail.com, [b] suprety@ioe.edu.np, [c] barsha.shrestha@pcampus.edu.np

Abstract
Buildings account for between 30 and 40 percent of the total end use energy. Therefore, using energy within the scope of basic needs and transforming initial designs into greener and more sustainable methods can have a significant impact on the management of energy resources. Individual homeowners and building users who invest in energy efficiency often see a quick return on their investment due to lower energy costs. Because a new building's efficiency will influence its energy consumption until it is renovated, or even for the rest of its life. Thus, It is essential to identify the key factors that are affecting the limit of energy usage in buildings so that any minor to significant action plan may be developed to reduce Nepal's energy demand by the building sector. Changes in the design process, on the other hand, can incorporate energy efficiency from the start. This involves an understanding of the parameters through which design is influenced by both the client and the architects.

Keywords
energy efficiency, energy policy, design process, building design

1. Introduction

Energy efficiency has become one of the growing issues all over the world. Cities account for about two-thirds of global primary energy consumption, which offers significant potential to optimize renewable energy production and enhance energy efficiency in urban planning. For example, a careful consideration of building site orientation and other passive strategies could lead to energy savings of 20 percent – 50 percent [1]. Building sector is considered the biggest single contributor to world energy consumption. In Nepal, the energy consumption by residential buildings accounts for 80percent of the total energy consumption of national consumption.

In Nepal, there is a very high urban growth rate. This means people's choice of living standard changes with the time to urban lifestyle with access to modern technologies most of which are a consumer of energy. It is estimated that an additional one million houses will be constructed between 2011-21. For this, fifty-five billion bricks i.e. more than twenty-three hundred tera-joule energy will be consumed [2].

The building sector is also one of the main contributors to greenhouse gas emissions, raw material consumption, and one of the most energy-intensive sectors worldwide [3]. Furthermore, buildings are essential for citizens' well-being and quality of life because they have a significant impact on health and are a fundamental feature of the built environment. This requires a transformation of the most important sectors, such as the construction industry, to improve energy efficiency, resource efficiency, and emissions reduction. As a result, the architecture, engineering, and construction industries must adopt sustainable and energy-efficient methodologies and technologies.

In the construction of an energy-efficient building, both the client and the architects play an equal role. To construct such an energy-efficient structure, it is essential to fully understand an architect's thought process and all of the factors that go into the design's early decision-making. This requires an understanding of the parameters through which the client and architect influences design.

2. Methodology

The research lies within post-positivist paradigm and hence cor-relational research strategy was used to carry out the study to understand the influence of both client and designers and other parameters such as cost, bye laws, simulation tools and general knowledge in design process of a building. We conducted a survey among the architects who are working professionally to investigate their existing practice, needs, and limitations in an early design stage. Using a structured questionnaire, an online sample survey was carried out. The sample frame of hundred respondent architects was taken from the members of Society of Nepalese Architects. The sample size was distributed among Architects of varying ages from twenty to above fifty. Table 1 shows the distribution of samples among aforementioned groups.

Table 1: Sample distribution

Category	Sample Distribution
Age Group (20-30)	59
Age Group (31-40)	22
Age Group (41-50)	16
Age Group (50+)	3

The survey form did come with a cover letter explaining the study and its purpose, as well as an explanation that the respondents' answers would be anonymous and that their contact information would not be used outside of the study. The survey was conducted for three weeks starting August 1, 2020. The questionnaire consisted of twenty-five measurements that were either yes/no questions, multiple choice or the ratings that are weighted on a scale of 1 to 5. Details of the sections are below:

• Part A: General information, the background of the respondent and experiences were included in this part.

• Part B: This section included the knowledge of architects and workflow. It also inquired about client influences in design decision making.

• Part C: This section inquired about the knowledge of energy modeling tools and its work-ability. It also included the energy efficiency adaptations taken in considerations and the influences of the client.

• Part D: This section inquired about the reasons for not adopting energy modeling into their design process and the possibility of use of such tools for bringing energy efficiency in design.

3. Literature Review

The urban residential sector consumes 14.5 percent of total residential energy consumption [4]. Cooking consumes about 52 percent of urban energy, followed by electric appliances (14 percent), lighting (13 percent), heating and cooling (10 percent), animal feeding (8 percent), and agricultural processing (8 percent) (3 percent). In addition, the author calculated that energy consumption is growing at a rate of about 2.3 percent per year. This implies that a small reduction in building energy use would have only a minor impact on the nation's energy use [5]. As a result, keeping energy use within the bounds of basic needs and shifting early design to more sustainable approaches can have a big impact on energy resource management. However, it is critical to identify the major factors that determine the limit of energy use in buildings so that any minor to major action plans to reduce Nepal's energy demand can be developed.

Building owners or buyers of new buildings may mistakenly believe that a building's efficiency is excellent when it is not. Buyers, in particular, may mistakenly believe that new constructions are automatically so much more efficient that no further action is required [6]. This could halt increased efficiency in new buildings because consumers believe that existing products and structures are already efficient. The concept of design phases refers to a series of actions that follow one another to guide the development process. Each phase of the project is shaped by these actions, which are organized into stages based on their priority level. In order to implement each action/goal/objective at the appropriate time, it is necessary to consider the value of each action/goal/objective, predicting its importance on the building's performance and its impact on the project's final cost. A performance approach is essential to manage the life cycle requirements of a building during its conception [7].

Building materials can be classified according to usage in the building components, i.e. foundation materials, walls, upper floors/attic floors, earthquake resistant elements. Different types of materials can be used in different components. For example: stone, brick, concrete block, stabilized earth block as wall material. In total, the Nepal Reconstruction Authority listed 13 types of non-wall materials and 5 types of roofing materials. For wall including stone, brick, local coniferous wood plank, interlocking brick, hollow cement concrete block, compacted stabilized

earth block, crushed stone block, thin steel, lightweight aerated concrete brick, fiber cement board, gypsum board, calcium silicate board. Likewise, for the roof, we find slate, stabilized mud, RCC sheet, CGI sheet metal and terracotta tile. To produce different types of materials, different types of organic and inorganic raw materials are required.

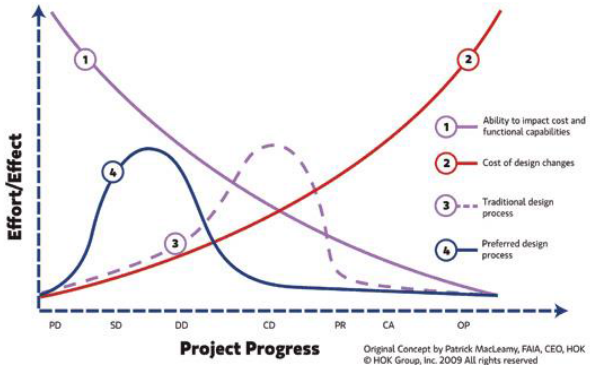

Figure 1: Impact and cost of planning

The International Energy Conservation Code, for example, specifies the criteria for SHGC based on climate zone, orientation, and solar shading projection factor [8]. U.K. Building Regulation Part L2A limits the effects of solar gain in summer by specifying the criteria for the solar gain through the glazing compared to that through the reference glazing. Building Code of Australia specifies the criteria for the aggregate air-conditioning energy value with regard to SHGC, U-value, glazing area, energy constant for the specific orientation, and heating and cooling shading multiplier.

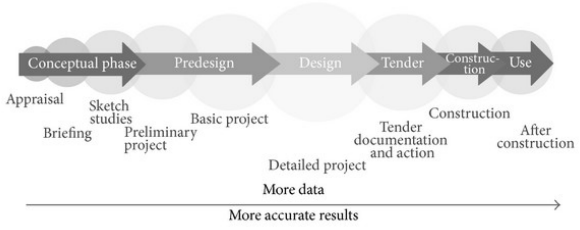

Figure 2: Architecture design process

The knowledge and skills needed to analyze building energy are lacking among aspiring architects. They always base their decisions on personal experience and conduct qualitative research. WWR (window-to-wall ratio), SHGC, U-value, VT, shadings, day-lighting control, and other design parameters all influence the energy performance of windows. The thermal and visual comfort of occupants is also affected by these variables.

There are a number of government policy interventions related to energy efficiency. The three-year plan 2010-13 addresses the need for energy efficiency and the government's commitment to further progress towards greater efficiency in the energy sector. Given the lifespan of most buildings, the relative energy efficiency of new buildings will affect energy use for many years. Energy efficiency upgrades can reduce the need and cost of heating and cooling systems. In addition, a well-designed climate- and energy-aware building can provide a diverse solution to address energy needs and operate sustain ably and efficiently. Combinations of different aspects of passive solar design can easily be incorporated into new buildings depending on location, building orientation and local climatic conditions.

Likewise, the use of proper day lighting design can lead to a significant reduction in the use of artificial lights during the day and thus the energy consumption of buildings for lighting. And using energy more spontaneously can also reduce costs. However, in Nepal there is no written rule on building energy. All available codes cover security areas only. A better understanding of policy-making in the built energy sector is therefore an essential aspect in mitigating any future energy crisis. Energy consumption for space heating in a building can be reduced by up to 80percent if orientation, building shape, insulation and ventilation are optimized during the design process [9].

4. Analysis and Findings

The sample of 100 architects who responded the survey is fairly diversified in terms of background (age, experience, ethnic group). Out of the 100 architects who responded to the survey, 59 percent are young architects with 1-5yrs of professional experience, 22 percent are intermediate architects with 5-10yrs of experience and 19 percent are experienced architects with 10+ years of professional experience. (70 percent) Most of the architects who responded to the survey are known to energy efficiency and had a training or course related to energy efficiency while 30 percent of the surveyors had no trainings in energy efficient building or green building technology.

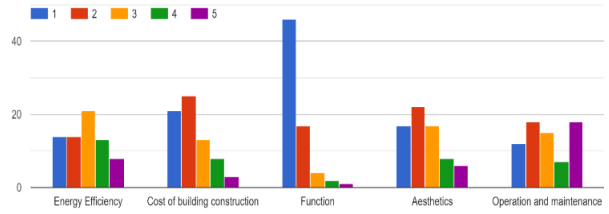

Figure 3: Important criteria in design process for architects

When questioned about the sequence of their design process, the majority of the architects said that they first look into function of spaces (42 percent), followed by orientation (40 percent), followed by assessing the building structure. Once all this is decided, they choose the building materials. Queries regarding on different influencing factors for built-up area revealed that requirements of client, functions, site conditions along with respective bye-laws have almost equal contribution for the area of the building. Orientation was not regarded as an important factor to influence the design area. 61.3 percent architects replied that the mechanical heating and cooling system of the designed area is depended on clients' requirement and only 38.7 percent replied it depends on design requirement.

Around 41 percent of the response revealed that means for active heating and cooling system were moderately considered when designing a building whereas 40 percent did not think likewise. Only 19 percent of them agreed that provision of active heating/cooling system were considered in building design process.

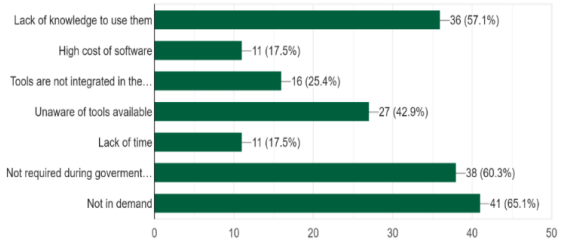

Figure 4: Reason for not using energy modelling in design process

More than 60 percent of the respondents expressed that functional requirement are the most important criteria in the design process, followed by cost of construction.

Around 20 percent of the respondents expressed that energy efficiency is also an important criterion in the design process whereas operation and maintenance were regarded as the least important one.

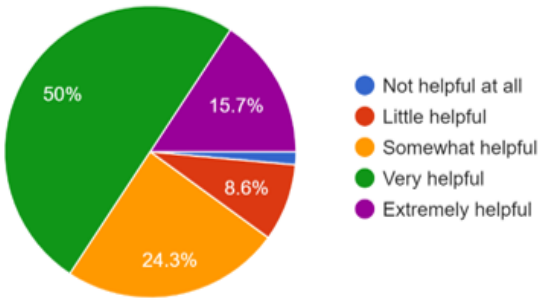

Figure 5: Importance of energy modelling in design process

Around 85 percent of the respondents expressed that energy modelling is not used in the design process. The major reason for this was energy modelling is not demanded much by the client (65 percent) as well as during approval process (60 percent) for building permit. Also, limited knowledge on their use (57 percent) and unawareness on the availability of tools (42 percent) were other major reasons.

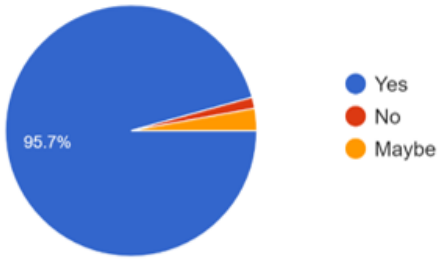

Figure 6: Importance of building policies in design process

50 percent of the respondents believed that energy modelling and energy efficient building technologies were very helpful in deigning energy efficient buildings whereas only 10percent of them thought of them as unhelpful. 78 percent of the respondents believed that energy modelling tools and strategies are helpful during early planning stage of the design process whereas 20 percent thought it was helpful during detailed design or design development phase. Almost every respondent believed that formulation of building policies and regulations are important for designing and constructing energy efficient buildings.

80 percent of the respondents expressed that

development of policies and regulations could encourage clients and designers to use energy efficient technique. Around 89percent of the respondents expressed that local authorities are not being responsible enough to address the need of energy efficient buildings at present. In addition, around 71 percent of the respondents expressed that they did not have any knowledge on existing policies related to energy efficient building.

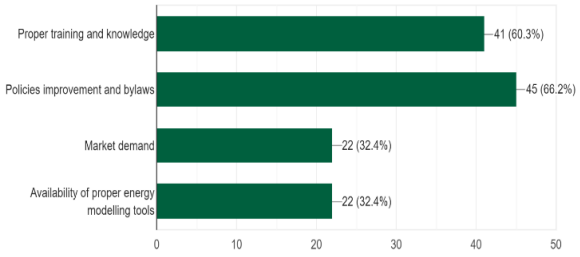

Figure 7: Reasons promoting energy efficiency in context of Nepal

Development of policies and bye-laws along with its implementation and monitoring strategies (62 percent) and proper training and knowledge (60 percent) were expressed as major factors for promoting energy efficiency in building design. In addition, enhancing knowledge on availability of energy modelling tools and creating its demand is necessary.

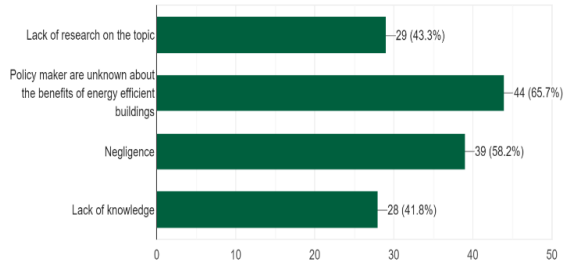

Figure 8: Barrier for formulation of building byelaws in context of nepal

Unawareness regarding the benefits of energy efficient buildings and its need at present age is the main barrier for formulation of building policies according to 66percent of the respondents. Similarly, negligence (58 percent), limited knowledge (42 percent) and limited research on these issues (43 percent) were another major factor contributing to this.

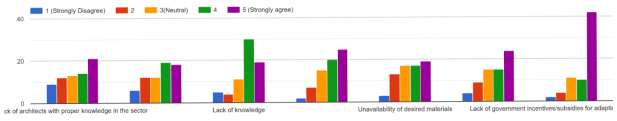

Figure 9: Reason effecting energy efficiency preference by clients

When asked about the reason affecting energy efficient consideration by clients, 73percent of surveyors concluded it is because of the lack of subsidies and incentive by the government, most of them also expressed the lack of knowledge could be a reason.

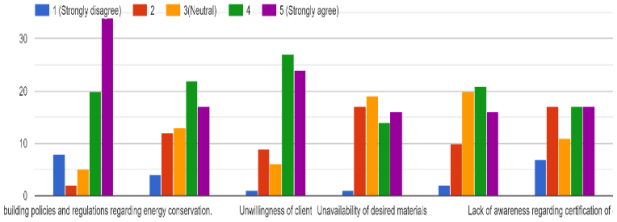

Figure 10: Reason effecting energy efficiency preference for architects

When asked about the preference of energy efficient consideration by architects and designers, 83percent surveyors agreed it is because of the lack of energy efficient building policies and regulations, most of them also expressed unwillingness of client to be a major reason.

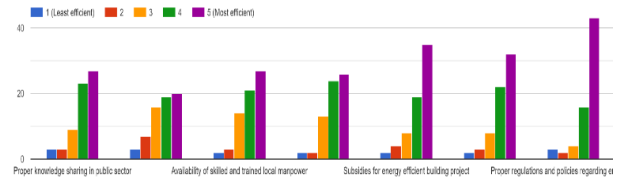

Figure 11: Solution for energy efficient building preference

When asked about the effectiveness of solutions for considering energy efficient strategies during design process 86percent of surveyors agreed formation of proper energy efficient building policies and 77 percent of surveyors agreed regulations and provision of subsidies for clients could be the most efficient solution. Most of them also agreed on provision of

proper research institute and awareness programs could be an efficient solution.

5. Discussion

Client's influence in the design process can be seen as significant from the early design stage. Sixty-five percent of respondents agree that the designed area is dependent on the client's requirement. As 85 percent of respondents do not use any energy modeling tools, the significance of material choice in energy performance might not be confirmed. It was observed that the use of mechanical heating and cooling is mostly guided by client's choice.

As 68 percent respondents ranked energy performance in the lowest order of priority in design discussion, it might signify that although the design discussions and design process consider cost, function and aesthetics, the energy performance of the designed building as well as the operational cost and maintenance is not prioritized by the architect in current trend. This is also verified by the response regarding the use of energy modeling in the design phase where most of the respondent replied that it is not required by the client. Only 55 percent of respondents said they agreed with the requirement to use energy modeling during the design process, while 24 percent said they were neutral and 10 percent said they disagreed. The lack of demand for such tools was cited by 65 percent of respondents as the primary reason for not using them. Furthermore, because energy simulation modeling is not required during any legal proceedings, both the client and the architect disregard it.

It was found that 79 percent of the respondent felt building policies and regulations can encourage both client and architect in using energy efficient building techniques. However, the implementation of energy efficient technologies is dependent on the architect's choice as 63 percent respondents agreed upon this which is followed by the client's choice with 80percent agreed upon this. The responses suggest that the preference for energy efficient buildings is primarily influenced by the client's preferences, followed by government bylaws and codes. In Nepal, incentives and subsidies for clients, as well as clear guidelines for architects, may aid in the adoption of energy-efficient design strategies. Secondary reasons include a lack of proper research institutes and a lack of public awareness about the benefits of energy efficient building design.

6. Conclusion

The architect's perception of the building is more or less in line with the client's communicative references, indicating that the client is actively involved in the design discussion and process. It is well observed that the architect takes into account most of the client's preferences but energy efficiency and energy optimization being the least preferred criteria in design discussion, it is always considered minor in the design process.

The market will not invest in energy efficiency options if energy efficiency does not rise as a requirement for energy development. Minimum efficiency standards, according to [10], can be a very effective strategy for encouraging larger-scale energy efficiency improvements. Changes in the design process, on the other hand, can adopt energy efficiency from the start. This may necessarily involve the use of an energy modeling tool to allow for effective communication between the architect and the client in order to achieve energy optimization and adaptation. From the initial design phase to the building operation phase, a project's performance must be evaluated for cost optimization.

The creation of building policies is critical at this time, and proper research institutes for energy analysis and client awareness programs are the most crucial aspects for architects and designers to implement building energy efficiency.

Building policies and regulations, on the other hand, must include incentives and subsidies for clients to encourage them to adopt energy-efficient design measures. Furthermore, policymakers must now take building energy efficiency seriously and recognize it as a critical criterion for controlling energy in the country

References

[1] Sujit Kumar Sikder, Francis Eanes, Henok Birhanu Asmelash, Shiba Kar, and Theo Koetter. The contribution of energy-optimized urban planning to efficient resource use–a case study on residential settlement development in dhaka city, bangladesh. *Sustainability*, 8(2):119, 2016.

[2] Dr. S. Shrestha. Un habitat nepal g b training. Technical report, 2011.

[3] Rúben Santos, Antonio Aguiar Costa, Jose D Silvestre, Thomas Vandenbergh, and Lincy Pyl. Bim-based life cycle assessment and life cycle costing of

an office building in western europe. *Building and Environment*, 169:106568, 2020.

[4] Jens Laustsen. Energy efficiency requirements in building codes, energy efficiency policies for new buildings. iea information paper. 2008.

[5] A. M. Nakarmi. Future energy scenario and implications for technological interventions for nepal. *Proceedings of IOE Graduate Conference. Kathmandu, Nepal: Institue of Engineering, Tribhuvan University.*, 2013.

[6] Hindawi. 2014.

[7] Pernilla Gluch. The life cycle costing (lcc) approach: a conceptual discussion of its usefulness for environmental decision-making. *Building and Environment*, pages 571–580, 2004.

[8] Hui Zhang. Research on climate adaptability of energy conservation building with renewable energy sources in hot-summer and cold-winter zone of china. *Applied Mechanics and Materials*, pages 1289–1296, 2013.

[9] W. Feist, J. Schnieders, V. Dorer, and A. Haas. Re-inventing air heating: Convenient and comfortable within the frame of the passive house concept. energy and buildings. pages 37, 1186–1203, 2005.

[10] H. Geller. Polices for increasing energy efficiency: Thirty years of experience in oecd countries. *Energy Policy, vol. 34, no. 5*, page 556, 2006.