Practising energy efficient design for commercial buildings in Sri Lankan industry

Maximus Navam Fernando,
Department of Building Economics, University of Moratuwa
(email: maxiqs@gmail.com)
Himal Suranga Jayasena,
Department of Building Economics, University of Moratuwa
(email: suranga@becon.mrt.ac.lk)

Abstract

The building industry is constantly expanding with consequences on energy expenditure. As similar to the most countries, in Sri Lanka too building industry is the most Energy consuming Industry. In recent years there were much discussions regarding Energy conservation techniques to mitigate the demand side of the energy sector. Building design directly affects the energy performance of the building. The emphasis on energy Conservation has therefore, to begin at the design stage & control throughout the life cycle (Design, Construction, Operate and Maintenance) of the building project.

Buildings, energy and the environment are the issues that the building professionals have to address in current day projects. This is partly due to the increasement of public awareness on environmental issues related to building developments. Therefore, to achieve the energy efficiency goal, architects and building designers need to perform energy conscious designs in their relevant discipline. The expanded design team collaborates in early design stages to generate many alternative concepts for building forms, envelope and landscaping, focusing on minimizing peak energy loads, demand and consumption.

Purpose of this study is to find to what extent energy conscious design has been considered by designers in the Sri Lankan context, and to recognize the areas to be developed to achieve energy efficient building in the industry. The research methodology adopted was quantitative, within that questionnaires were used for detailed survey. A pilot study was conducted by through telephone interview prior to the detailed survey.

Through this research it is found that there should be mandatory energy guidelines enforced for the designers. In addition, designers' lack of knowledge on life cycle benefit; available technology; available energy efficient techniques; and non- usage of energy analysis tools are major hindrance to proceed to the energy efficient design.

Keywords: Energy Analysis Tools, Building Energy Code, Design Team, Energy Efficient design.

1. Background

In most of the countries, the building industry is the most energy consuming industry and it is constantly expanding with consequences on energy expenditure. Past twenty years of research effort had produced a consensus understanding of the impacts of energy consumption and the approaches to

reduce this impact by using energy efficiency and the deployment of renewable energy technologies. Especially the Building Energy Efficiency codes have been developed in many countries, and almost all developed countries have enforced them [1]. Further the building energy simulation tools are in rapid development and now been increasingly used in building designs [2]. Therefore, to achieve the energy efficiency goal, architects and building designers need to design energy conscious designs in their relevant discipline. Hence this research is aimed to find what extent energy conscious design has been applied by the designers in the today's buildings in Sri Lanka.

In Sri Lanka, the demand for electricity is rapidly increasing. In the year 2004, electricity demand growth rate varies between 7% - 8%. Average Electricity consumption per capita is 348Kwh/person at the same period and it has grown by 8% from previous year [3]. It was forecasted that electricity demand will quadruple in the next 15 years. However the last few years have seen the power generation of the country gradually shifting more towards thermal power generation. In 2004, Gross power Generation increased by 5.68% but gross generation of hydropower plants were reduced by 13.63% at the same period [4]. It is estimated that by 2014, 82% of the total electricity demand will be met by thermal power generation [5]. At the same time, Authorities are finding very difficult to construct thermal power plants in the face of rising opposition from the local people on economic and ecological grounds.

In Sri Lanka main sectors of energy consumption are Industrial, Transport, household and Commercial and others (religious organizations, etc.). According to the Energy Conservation Fund (ECF) [6] for year 2003, percentage of consumption of Household and Commercial sector was 51.10 % when compare with the other two sectors at Industry and Transport which are respectively 24.41% and 24.80%. Among these, the rate of increase in energy demand in the commercial sector is the highest due to the rapid development of the sector, changes in life styles, contemporary architectural practices and lack of suitable energy saving technologies and building management/automation systems. Due to these reasons, the present annual electricity consumption in commercial buildings, which is approximately 1000GWh, is expected to increase by 28% of the total electricity demand [5].

According to the demand side Management, the energy demand in this sector can be reduced by applying various energy conservation techniques throughout the life cycle of the building. Passive cooling, shading and sun control, efficient daylighting and Heating, Ventilation and Air Conditioning (HVAC) systems, active solar and photovoltaic system are some of the main energy conservation technique. As per the ECF, domestic and commercial sector have 12% of conservation potential from the total annual consumption that potentially saves Rs 2.4 billion annually [6]. According to the UK Department of Energy Estimates that, the better design of new buildings could produce energy consumption reductions of 50% and that appropriate design intervention in the existing stock of buildings could result in a 25% reduction in energy consumption ([7]). The electricity cost in most of the high rise buildings in Sri Lanka are generally are 50% of the monthly operating budget [8]. Any reduction in energy cost will have greater impact on per square feet cost of the building. This will enable the building owners to reduce their office rentals. That will provide them a competitive advantage, especially when competing with smaller office buildings this overhead are comparatively low.

Therefore, to achieve resource conservation and efficient energy management in this area requires effective retrofit and innovatory design measures. By effective implementation of such measures, the commonly agreed and achievable target reduction is around 30%, with more optimistic expectations - up to 70% - for buildings incorporating advanced technology features [9]. However, such strategies and technologies have not yet been widely adopted by the construction industry. The majority of

buildings are still been designed without energy-related considerations beyond those enforced by energy codes. One reason for this is that practitioners do not have the means to assess the impact of new strategies and technologies during the design stage.

The sustainable development has become a Global focus in present day industry. Buildings, energy and the environment are issues that the building professionals have to address in current day projects. This is partly due to the increased public awareness of environmental issues related to building developments. Therefore, to achieve the energy efficiency goal, architects and building designers need to design energy conscious designs in their relevant discipline.

2. Sustainable Design

Sustainable design is the thoughtful integration of architecture with electrical, mechanical, and structural engineering. In addition to concern of the traditional aesthetics of massing, proportion, scale, texture, shadow, and light, the facility design team needs to be concerned with long term costs: environmental, economic, and human.

The Rocky Mountain Institute [10] outlines five elements for sustainable design:

- Planning and design should be thorough. Sustainable design is "front loaded" compared with traditional design. Early decisions have the greatest impact on energy efficiency, passive solar design, daylighting, and natural cooling.
- Sustainable design is more of a philosophy of building than a prescriptive building style. Sustainable buildings do not have any particular look or style.
- Sustainable buildings do not have to cost more, nor are they more complicated than traditional construction.
- Integrated design, that is design where each component is considered part of a greater whole, is critical to successful sustainable design.
- Minimizing energy consumption and promoting human health should be the organizing principles of sustainable design. Other than the above elements for sustainable designs are energy saving architectural features, energy conserving building envelope, and energy-efficient and health-promoting mechanical, electrical, and plumbing systems.

The main objectives of sustainable design are to avoid resource depletion of energy, water, and raw materials; preventing environmental degradation caused by facilities and infrastructure throughout their life cycle; and to create built environments that are livable, comfortable, safe, and productive.

3. Energy conscious design in Sri Lankan context

To achieve sustainable development, one of the major contributions has given through designing energy efficient buildings. Therefore practicing and developing the energy conscious design enhance to produce more energy efficient buildings. This research is aimed to find the practice in the energy efficient design in building industry in Sri Lanka. Due to the broad scope of energy efficient design, this initial research is focuses on identifying energy conscious design discipline of architectural and services designers from the building sector and considering mainly commercial building in the Sri Lankan industry. The aim of this research will be addressed:

- To identifying the energy conservation techniques and design tools and other measures to achieve energy conscious design.
- To identifying the measures taken to achieve the energy conscious design and their impediments factors.
- To investigate the level of consideration on the energy efficient design by the designers.
- To recognize what areas should be developed in the industry towards crafting energy efficient buildings.

4. Research Methodology

The research methodology for this study adopted was quantitative. Initially the pilot study was conducted by telephone interview to find out the designer's consideration to the energy efficient design and the usage of energy analysis design tools. Then detailed survey was conducted within that closed questionnaires used. It includes fixed responses option as Likert scales. This was used to identify what extent that energy conscious design has been practised and what level it has considered in current context. Unstructured interview was not suitable since the scope of study is limited to find the level of practised and not in detail in depth as case studies. Structured questionnaire survey is conducted with selected thirty samples which included in the pilot study sample. Fifteen number of professionals related to Architectural designs had been interviewed, and the rest of the fifteen professionals were interviewed in Services Design such as Electrical and Air Conditioning discipline.

Descriptive statistical method was used for the analysis of data which were collected from structured interview. The levels of responses incorporated with the statements were given weightages to convert this ordinal set of data to numerical figures. Further for descriptive statistical measures, viz. the minimum, maximum, median and the quartiles were used in analysis. A graphical box diagram as given in following example is used to present this parameters for easy comprehension (Figure 1):

What do you think about energy efficient design?

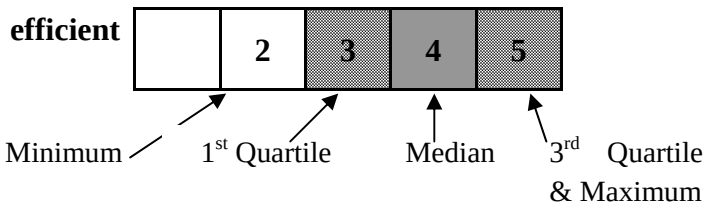


Figure 1: Box Diagram

Explanation: This box diagram can be interpret as, 50 percent of the responses have considerable knowledge in energy efficiency design. Less than 25 percent of the designers have some idea on that and at least one of the designers would have heard about the energy efficient design. Further there were some designers who have thorough knowledge in the energy efficient design.

Further Mann-Whitney U test have been used to identify the significant differences between two independent groups of sample as Architects and Services Engineers.

5. Research Findings

5.1 Results from the designers

The analysis of the responses of the designer reviled the following results.

Q1	What do you think about energy efficient design?		2	3	4	5
Q2	Do you think that is practical to achieve?			3	4	5
Q3	To what extent client consider through out the design phase?	1		3	4	5
Q4	Does the client allocate sufficient funds for energy efficient designing?	1	2	3	4	
Q5	Do you think that clients are not sufficiently aware of issues such as renewable energy and energy efficient buildings?	1		3	4	

According to the diagram Q1, it can be seen that at least 50 percent of the designers have some idea regarding energy efficient design. The 25 percent of the designers have considerable more knowledge on that. And every designer has at least heard about energy efficiency design. And there are designers who have thorough knowledge in energy efficiency design.

According to above diagram Q2 shows that all the designers somehow believe that it can be practically achieved and 50 percent of designers have confident that energy efficiency can be achieved frequently at operational stage which would be anticipated in the design stage.

According to above diagram Q3 shows, 50 percent of the designers believe that some how client consider energy efficiency measures throughout the design phase without concerning only at the initial stage.

The above diagram Q4 shows that, more than 50 percent of the designers reflect that the client rarely allocates sufficient funds for the energy efficient design at the design stage and at least 25 percent of the designers state that client never allocate sufficient funds for energy designing.

From above diagram Q5 it represents that, more than 50 percent of the designers responds that only some of the clients does not have average awareness on issues such as relevant to energy efficient designing and renewable energy. Its specially need to consider that none of the designers said that all the clients do not have sufficient knowledge on energy related issues. So which can be interpreted as most of the clients have considerable awareness related to the energy efficient issues.

From above diagram Q6, it explains that 50 percent of designers believe that some clients are voluntarily adopting the energy efficiency measures without any financial incentives and nearly 25 percent of the designers express that client are less likely to adopt energy efficient measures without financial incentives and education on the costs and benefits.

Q7. Do you think that the followings will be required to insist clients and designers to consider the energy efficient designing?

a.	New building regulations or legal enforcement are required.			3	4	5
b.	New mechanisms and incentives are		2	3	4	5

required to encourage clients to invest in

		3	4	5

c. Provide sufficient information and knowledge to client and designer regarding the energy efficiency.

		3	4	5

d. Provide enough access to the resources, products, information and skilled assistance regarding energy.

		3	4	5

e. Provide training and education to state and local officials, private industry, and consumers.

According to this diagram Q7 represents, that 75 percent of the designers considerably agree that new building regulations or legal enforcement; provide sufficient information and knowledge; increase the availability of the energy efficient products; provide training and education will be required often to insist to consider energy efficient designing. Further 50 percent of the designers expressed that new mechanism and new incentives often insist the client and designer to go for energy efficient design.

Every designers express that these above factors are much more needed to insisted to clients as well as designers to proceed with the energy efficient designing. Most of the designers expressed that statutory requirements will help level of playing field for developers and builders as energy-conscious designers and building professionals will not have to compete with others who achieve construction cost savings by eliminating or ignoring energy-efficient features in their design. Some architects believe that mandatory standards limiting the design freedom and innovations if the Building Energy Standards are not comprehensive and flexible enough.

Q8 Do you think that time taken for design is high for achieve clients energy efficient requirement?

1	2	3		

Q9 Do you think that design cost is high for achieve clients energy efficient requirement?

1	2			

According to the diagram Q8 and Q9 it shows that, only 25 percent of the designer's states that design time is never long for energy efficient designs and when compare with design cost more than 50 percent of the designers stated that design cost was never high. And none of them states that design cost and time duration of the energy efficient design were always high.

Q10 Do you think that time taken is long for constructing energy efficient buildings?

1	2	3		

Q11 Do you think that integration design process by using in-house professionals will enhance the energy efficient design?

1		3	4	5

According to the diagram Q10, it shows that 25 percent of the designers states that construction time is never long as well as 50 percent of the designers expressed rarely time increased for construction of the energy efficient buildings.

As per the diagram Q11, it shows that the 50 percent of the designer's states that the integration design process by using in-house professionals will sometimes enhance the energy efficient design. Only 25 percent of the designers states that it often enhance the energy efficient design. Further it is found that, some of the designers described that it depends on the availability of communication modes in the organization. Even though the professionals are separated the design process will be enhanced by proper communication system between these professionals.

Q12	Do you set energy performance goal?	1	2			
Q13	Do you follow any checklist to achieve this goal?	1	2			
Q14	Do you use any technique to evaluate energy efficient design?	1	2			
Q15	How often the proposed alternative designs has been agreed by the client?	1		3	4	5
Q16	How often the proposed alternative designs has been agreed by the other design professionals?	1			4	5

From the box diagram Q12, Q13 and Q14 represents, that the similar responses obtained for to above three facts. Where more than 75 percent of the designers are do not use any check list to achieve energy efficient design goal; do not set energy performance goal and do not use any technique to evaluate their design.

From the box diagram Q15 and Q16 represents, 75 percent of the designers states that the alternative designs proposed by them has been agreed by other professionals but it is 50 percent in case of client. In case of energy efficient designs the clients is the most influence on decision making process in case of alternating the proposed designs.

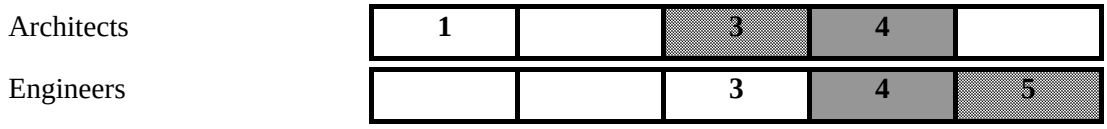
5.2 Results from the Engineers and Architects

1. Do you think that there is sufficient energy saving technologies available in the current market?

Architects	1	2	3	4	
Engineers	1		3	4	5

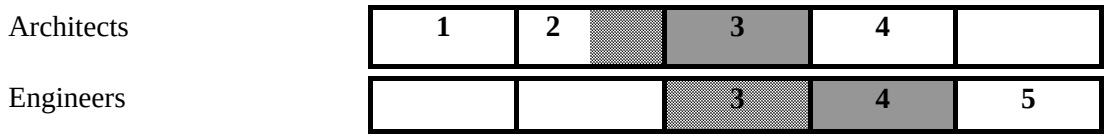
According to this diagram, more than 50 percent of the Architects state that the energy saving technologies are rarely available in the current market. However, 50 percent of the Engineer states that energy saving technology available often in the market. Some of the Engineer states that there are always sufficient energy saving technologies available in the market but in the other case of none of the Architects mentioned as it is.

2. To what extend energy efficient requirement of the client succeeded?



According to the Box diagram, the more than 75 percent of the Architects states that client succeeded with his requirement very often. But there were no Architects who response as always it is succeeded. But in the case of Engineer it was found that more than 25 percent of respondents state always the client succeeds with his initial requirement. At least every Engineer has a confident that energy efficient design was considerably succeeded with the client initial requirement.

3. Do you think that construction cost is high for energy efficient buildings?



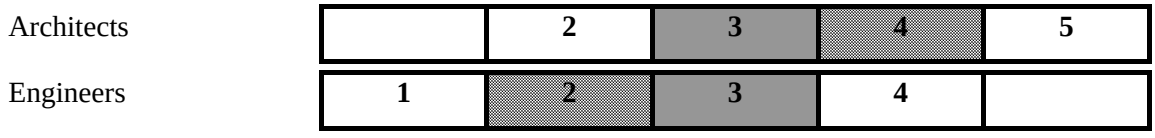
From the above diagram it represents as, 50 percent of the Architects states that sometimes the construction cost is high for the energy efficient building. In meantime, within the Engineer states at least for somehow construction cost is high.

4. Does designer follow any guidelines to achieve energy efficient designing?

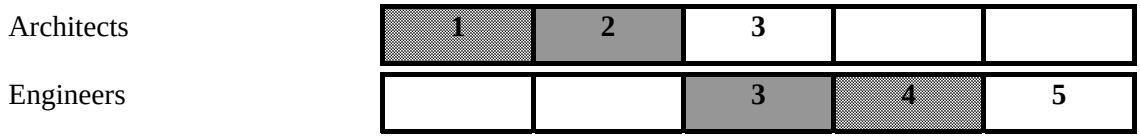
From the diagram it can be found that more than 50 percent of the architects have never follow any guidelines related to energy efficient design. At the same time, 50 percent of the Engineer has somehow follow guidelines such as Energy Efficient Building Code (EEBC) in their design. While their questioning it was found that EEBC was not popularize among the design professionals especially Architects.

5. What extent the designers use following techniques to achieve energy efficient building?

a. Incorporate solar passive techniques in a building design to minimize load on conventional systems

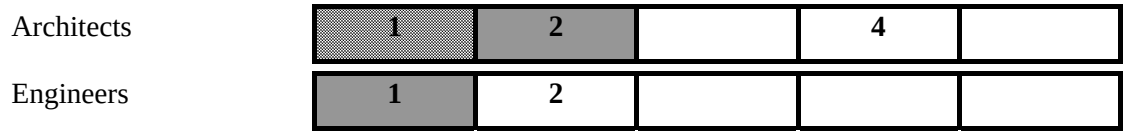


b. Design energy efficient lighting and HVAC systems



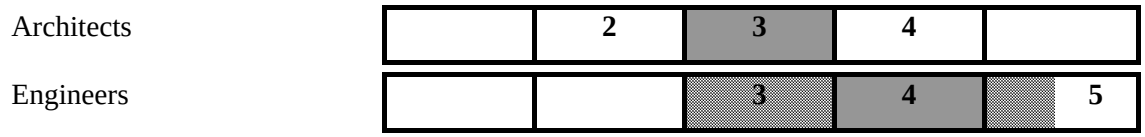
From above two diagrams that it clearly shows that Architects and Engineers have different level of knowledge on techniques used to achieve energy efficient building. Its clear that more than 50 percent of the Architects have some idea on that solar passive techniques in a building design to minimize load on conventional system when compare with the Engineers, who have less than 25 percent. It is vice versa in the case of designing of energy efficient lighting and HVAC system. From this its obvious that the Engineers have considerably high knowledge on HVAC system.

c. Use low energy materials and methods of construction & reduce transportation energy (reducing embodied energy)



When we consider the technique of using low embodied energy materials to achieve energy efficient in the building, none of the professionals have through knowledge on that. Especially 50 percent of the Architects have less knowledge on that but in the case of Engineers have no idea about it.

d. Use renewable energy systems (Solar photovoltaic systems/ solar water treating systems) to meet a part of building load.



The above diagram indicates that more than 50 percent of the Engineers have considerable knowledge on the use of renewable energy systems to achieve energy efficient in the buildings. But more than 75 percent of the Architects have some idea on that.

6. Conclusions

This study was conducted to identifying the designers concern towards the energy responsive design in building industry. Nowadays the world focuses on sustainable development. Hence the designers focusing more on the sustainable design with respect to the construction industry. The awareness regarding the energy efficient design is very important in the present day design scenario. Most of the designers should consider it not only by considering the benefit of the clients but should need to consider the society's benefit as well.

As an initial measure to reduce the demand side energy was taken by introducing EEBC as voluntary guidelines to the Sri Lankan Building industry in the year 2000. However till now it has not developed and the implementation of that code is very rare in present day industry. Most of the designers expressed that the mandatory guidelines must needed to construct more energy efficient buildings in the future. They further expressed that the present EEBC should need to be updated and revised before it is practiced as a mandatory guideline. This should be implemented as soon as possible. This will encourage more designers and engineers to craft their design as energy conscious design in future.

Furthermore clients have been very reluctant to go for energy conscious design. Because most of the clients have misconception that construction cost was high for energy efficient construction by only

considering the initial cost. However it is not real in the present scenario. When considering the long run of the building it is found that energy efficient building is more economical than the traditional energy non-conscious buildings. Some of the designers have considerable knowledge on life time benefits of the energy efficient design and they have a high responsibility to convince client to go for energy conscious design.

In the Sri Lankan building industry, certain energy efficient design concepts are in practice such as solar gain control, efficient lighting, power factor correction etc. but technique like passive design techniques were not much familiar among the designers. Moreover it is found that technique to achieve energy efficient building, by using low embodied energy material, is not well-known among the designers. Most of the designers' state that due to non-availability of material and technologies in the market are also one of the main obstacles to go for energy conscious design.

However, in general most of the designers are not considerably concern in related to the energy efficient designs in their design discipline. In addition to that the knowledge regarding energy analysis tools also lack within the designers. And most of the designers believe that it is not practicable to use in Sri Lankan context. Hence providing education and training and other measures to familiarize the energy conscious design will be much more needed in the present day industry. In addition to the designers, the parties of the stakeholders such as local officials, private and public clients and consumers also necessary to be aware on the energy efficient aspects to save energy and provide vital economic and ecological benefit to the country like Sri Lanka.

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