ADOPTING NET ZERO ENERGY BUILDING CONCEPT TO REDUCE ENERGY COST OF COMMERCIAL BUILDINGS IN SRI LANKA

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ABSTRACT

Fulfilling energy demand has become a major challenge faced by most of high rise buildings today as it creates high utility cost to the organization. Hence, most of the organisations, especially in commercial building sector seek better options to fulfil their energy demand as a major energy consumer among the other building facilities. Hence, several energy management practices have been introduced to enhance energy efficiency. In the governing concern on less energy and less environmental impact, Net Zero Energy Building concept has received attention. Net Zero Energy Buildings have a greatly reduced energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources. However, the adaptation of this concept has become a major challenge due to various barriers. Therefore, the purpose of this research is to identify the barriers to adopt Net Zero Energy Building concept to commercial buildings in Sri Lanka for proposing probable solutions. As this research required a detailed investigation, case study approach was selected under qualitative phenomenon. Three cases were conducted in three selected commercial buildings to collect the data. Cross-case analysis technique was applied as the appropriate data analysis technique. Nvivo and Decision-Explore software's are used to analyse and present the data. As the focal point of the research, barriers to adopt Net Zero Energy Building concept was determined relating to five major categories, such as, financial, legal, policy, social, and technical barriers. According to case study findings, this concept is more suitable for new building constructions than the existing buildings, as it is more effective to adopt it at the early stage of the building. Further, major barriers include limitations of organisational internal policies, preference of organisations for short term profits, unawareness and government rules and regulations. Accordingly, a framework is developed to propose probable solutions. The developed framework gives a value to the research, as it could use as a firm base in both organisational and national levels to adopt Net Zero Energy Building concept to reduce energy cost of commercial buildings in Sri Lanka.

Keywords: *Net Zero Energy Building; Commercial Buildings; Energy Conservation; Barriers; Solutions.*

1. INTRODUCTION

With the rapid development of the world, more and more buildings are constructed by creating an ever increasing energy demand. This has raised serious environmental problems such as global warming, air pollution and acid rain (Iwaro and Mwasha, 2010). Therefore, various building energy regulations, energy standards, codes, taxes, and subsidies have being introduced by most of the countries to reduce energy consumption of buildings (Iwaro and Mwasha, 2010; Balaras *et al*., 2007). According to Laustsen (2008), both building codes and energy standards provide a guideline to maintain minimum energy requirements for energy efficiency in buildings. However, energy standards are subjected only to minimize energy cost of buildings which is not optimally reducing the effect on environment. From several years, Net Zero Energy Building (NZEB) concept has been received attention. The core idea of NZEB is that NZEB buildings can meet all their energy requirements from low-cost, locally available, non-polluting, renewable sources (Torcellini *et al*., 2006).

According to Kneifel (2010), NZEB has several benefits compared to other types of buildings. NZEB needs least cost for maintenance and operation. NZEB generates not only financial benefits from energy efficiency improvements, but also it reduces carbon footprint. This reduction is average 16% carbon

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footprint which greater than countries energy generate using coal and oil. Similarly in Sri Lankan energy context, commercial sector consumes about 23% electricity. Pathmasiri (2010) mentioned that 77.54% the energy is used for air conditioning, 15.97% is used for lighting, where 2.17% and 4.32% of energy are used for lift and office equipment respectively. After several attempts, the national policy and strategies are adopted by Sri Lankan Parliament to face the energy challenge in Sri Lanka (Munasighe, 2010). However, the NZEB concept is still new to Sri Lankan energy sector. Hence, the adaptation of this concept has become a major challenge, as most of the buildings are fulfilling their energy demand from national energy grid. Therefore, the purpose of this research is to identify the barriers to adopt NZEB concept to commercial high rise buildings in Sri Lanka. To fulfilling the above purpose, the rest of the paper is structured to present the secondary data gathered through literature, key research findings and solutions proposed with the framework developed.

2. LITERATURE REVIEW

2.1. NET ZERO ENERGY BUILDING (NZEB) CONCEPT AND ITS IMPORTANCE

As the definition given by National Science and Technology Council (2008, P.48), "net zero energy (commercial) building is a high performance commercial building, that is designed, constructed, and operated to require a greatly reduced quantity of energy to operate; meets the balance of energy need from sources of energy that will result in no net greenhouse gas emissions; and is economically viable". The US Department of Energy (2015, p4) defines the NZEB is "an energy-efficient building where the actual annual energy consumption from sources is balanced by on-site renewable energy." At net zero source energy, building is produced as much energy as it was consumed. When total source energy is calculated, both imported and exported energy are considered. As Crawley *et al*. (2009) by using renewable energy with the building footprint, within the site, energy sources available off site and energy generation within the site and purchase off-site renewable can be achieve for the net zero source energy building. Building owners are interested in net zero energy cost buildings because this method tend to use energy efficiency strategies and renewable energy as part of their business plan. In this method financial credits were received for exported energy (Torcellini *et al*., 2006). As Crawley *et al*. (2009) mentioned, by using renewable energy with the building footprint, within the site and energy sources available off site and energy generation within the site can achieve net zero cost building. Among those definitions "Net Zero Site Energy" definition given by Torcellini *et al*. (2006, P.7) is used in this research: "Net Zero Site Energy: A site zero energy building produces at least as much energy as it uses in a year, when accounted for at the site."

As Li *et al*. (2013) stated, NZEB helps to reduce use of conventional energy resources and the deterioration of the environment. Further, NZEB plays important role in sustainable development. According to Sesana and Salvalai (2013), more than 80% of the operation cost of the slandered building can reduce by this NZEB concept. Further, researcher pointed out that, more than 75% of life cycle cost is determined by the operation and maintenance cost. Accordingly, NZEB can be used to reduce the 60% of life cycle cost of buildings. NZEBs have a greatly reduced energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources such as, wind, biomass, solar, hydro-electric, geothermal, and ocean energy (Boyle, 2004; Doty and Turner, 2013; International Energy Agency, 2014). To become a net zero energy building, two main strategies are available. One is to minimizing the energy need for buildings from more energy-efficient measures whilst adopting renewable energy to meet the minimum energy needs is the second option available (Li *et al*., 2013). According to a study by Torcellini *et al*. (2006), on site and off site supply options are available to use renewable energy sources to become a net zero energy building. As Torcellini *et al*. (2006) further mention, use of renewable energy sources available within the building's footprint and at the site are onsite supply options where off site options include purchasing and using renewable energy sources which are available off site to generate energy on site. However, mostly in NZEB, enough renewable energy is generated on site to equal or exceed its annual energy use. NZEB needs two main strategies to minimize the energy need for buildings from more energy-efficient measures, and by adopting renewable energy to meet the minimum energy needs (Li *et al.*, 2013).

2.2. ISSUES IN CURRENT PRACTICE

The adoption of NZEB has become a major challenge faced by buildings due to various issues. According to previous literature reviewed, various categories of issues were identified to adopt NZEB concept. A study by Lindkvista *et al*. (2014) has founded out key issues as technical, financial, social, organization and legal related issues. As per the study by Brostrom and Howell (2008), technical, financial, policy and training are the key issues to adopt NZEB concept. Accordingly, five major categories of issues are identified (refer Figure 1).

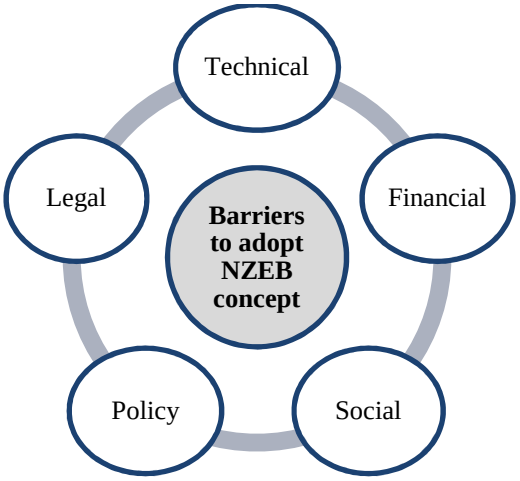

Figure 1: Barriers to Adopt NZEB Concept
Source: Lindkvista *et al*. (2014); Brostrom and Howell (2008)

2.3. ENERGY MANAGEMENT PRACTICE IN SRI LANKA

Currently, Sri Lanka also moves towards the energy efficient building concepts. According to Sustainable Energy Authority (2009), Clause 36 (g) of the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007, it empowers the Sri Lanka Sustainable Energy Authority (SLSEA) to specify and enforce a code of practice for buildings on efficient energy utilization. This code was applied to all commercial buildings, industrial facilities and large scale housing developments. As per the preliminary investigation, NZEB is a newest concept to Sri Lanka.

As the major renewable energy sources used, high proportion has been obtained by the hydroelectricity, wind energy, solar power and bio mass. However, in Sri Lankan renewable energy sector, it has mainly focused on grid and off grid power generation. Hydroelectricity is the most popular method used in grid power generation. Solar power, wind power and bio-mass are also used for the grid electricity generation, however not optimally. Hence, there is a less concern on adopting newest energy efficient building concepts. Further, few buildings have been concerned to adopt NZEB as a newest concept however; it has limited to use solar power due to several issues.

Therefore, as the focal point of this research, barriers to adopt NZEB concept were determined with special prominence to commercial high rise buildings in Sri Lanka. Accordingly, a theoretical framework is developed based on literature findings as illustrated in Figure 2. This was considered as the basic framework to evaluate the adoptability of NZEB concept in commercial buildings in Sri Lanka. As per the framework developed, current energy management practice in high rise commercial buildings was examined in order to identify existing practices and barriers to adopt NZEB concept to reduce energy cost of the building. The key categories of issues identified in literature, such as; financial, legal, policy, technical and social issues are acclimatized to evaluate the current practice.

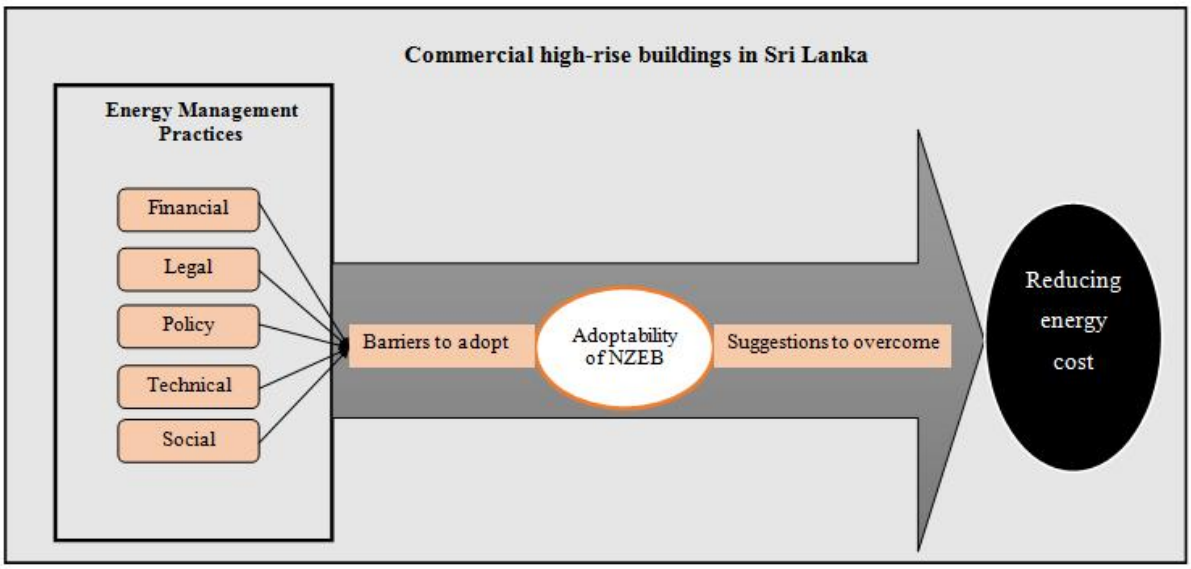

Figure 2: Theoretical Framework

The Section 3 describes the methodology adopted in this study.

3. RESEARCH METHODOLOGY

The research was designed as two stages. Literature review was conducted as the first stage by reviewing key research papers in the area of energy management with special emphasis to net zero energy buildings. As this research required conducting a detailed investigation into the energy management practices in commercial buildings and, its qualitative outcome, the research was conducted by case study method under qualitative phenomenon. According to Yin (2009), case study approach is more appropriate to bringing an understanding of a complex issue or object. In the case study design, three cases were selected under multiple case study approach. Hence, three high-rise commercial buildings were selected, those who have high energy consumption and have a concern on modern energy management practices.

Both direct observations and semi-structured interviews were selected as suitable data collection techniques. Eight semi-structured interviews were conducted among industry professionals who have involved in the field of energy management and net zero energy management practice in commercial buildings in Sri Lanka to collect the data. The interview profile is illustrated in Table 1.

Table 1: Interview Profile

Case		Designation
Case A	A1	Senior manager Operation and maintenance
	A2	Manager Mechanical and MVAC
	A3	Project Manager
Case B	B1	Maintenance Engineer
	B2	Mechanical Engineer
	B3	Assistance Maintenance Engineer
Case C	C1	Consultant Engineer
	C2	Assistance Consultant engineer

Code-based content analysis was used to analyse the case study data. QSR. NVivo and Decision Explorer software's are used to analyse and present the data. Cross-case analysis was conducted under two major headings as, barriers to adopt and solutions proposed. Figure 3 illustrates the coding structure developed to analyse the data.

Figure 3: Coding Structure

Section 4 presents the case study data analysis and key research findings.

4. RESULTS AND DISCUSSION

4.1. CURRENT ENERGY MANAGEMENT PRACTICES IN COMMERCIAL BUILDINGS

According to the case study data, most of commercial buildings are fulfilling their energy requirement thorough Ceylon Electricity Board (CEB) grid power generation. However, most of buildings have been implemented the various active and passive mechanisms to save energy and to reduce energy cost such as, passive design of the building, building orientation, building automation, Building Management System (BMS), installation of Variable Speed Drives (VSD), etc. At the present, use of renewable energy is still a newest concept for most of commercial buildings. As most of the interviewees responded, there is a management commitment to introduce renewable energy options to cater their energy requirement. Therefore, introducing NZEB to high rise buildings would be more effective to utilize their own renewable energy sources for reducing energy cost.

4.2. BARRIERS TO ADOPT NZEB CONCEPT

As the case respondents interviewed, high initial cost is a major barrier to adopt NZEB concept. As it proved by the Assistance Consultant Engineer in case C "*Initial cost is high in these renewable equipment such as solar panels, invertors*" Maintenance Engineer in case B also verified that "*The problem is the initial cost. Cost of renewable energy generation equipment is relatively high*." One of the other barriers identified was these projects are not aligned with the internal policy. It was clarified by Senior Manager Operation and Maintenance in case A as *"As our internal policy project which has payback period more than 2-3 year it was not viable project."* However, as argued the Consultant Engineer in case C *"We will have to find fund to installation solar system. Marginally it is nearly about 220 million so we have to get the approval but the recovery payback period is nearly 6 to 7 years."* So this project is not a viable project as per the internal policy. Among these eight participants, only two members were knowledgeable about the concept. Senior Manager Operation and Maintenance in case A has an idea about the concept however it is not total understanding. It was clarified by his statement as *"We have heard about it, but no clear idea. Can you brief on it?"* Most of them were not aware about this concept. For an example Mechanical Engineer in case B mentioned that *"Especially I haven't any experience in this concept."* Manager Mechanical and MVAC in case A also pointed out that unawareness of the concept is a key barrier to adopt this concept. Furthermore, less government and organizational policies, lack of space and lack of technology are also identified as barriers to adopt NZEB concept. As the key research findings acquired through cross-case analysis, key barriers are determined as shown in Table 2.

Table 2: Barriers to Adopt NZEB Concept

Key categories	Barriers identified		
	Case A	**Case B**	**Case C**
Financial	▪ High initial cost ▪ Longer payback period ▪ Resent of the investors ▪ Converting of old building is not economical ▪ High maintenance cost of the renewable power plant ▪ High transportation cost of biomass	▪ High initial cost ▪ Longer payback period ▪ High transportation cost of biomass ▪ High maintenance cost of the renewable power plant	▪ High initial cost ▪ Longer payback period ▪ Converting of old building is not economical
Legal	▪ No clear rules and regulation for off-site energy generation ▪ Less national level regulatory framework ▪ Getting approval is difficult	▪ No clear rules and regulation for off-site energy generation ▪ Getting approval is difficult	▪ Less national level regulatory framework
Policy	▪ Restriction from organizational policy ▪ Management concern about core business ▪ Less government policies	▪ Management concern about core business ▪ Less government policies	▪ Restriction from organizational policy ▪ Less government policies
Technical	▪ Lack of space ▪ Lack of expert knowledge ▪ Lack of suitable renewable resources ▪ Lack of technology ▪ Architectural designs ▪ Inadequate land raw material and other facilities	▪ Lack of space ▪ Lack of suitable renewable resources	▪ Lack of space ▪ Lack of expert knowledge ▪ Lack of suitable renewable resources ▪ Lack of technology
Social	▪ Unawareness	▪ Unawareness	▪ Unawareness ▪ Less management commitment and support

In order to adopt this newest concept to commercial buildings, these barriers are required to be eliminated. Hence, according to the different views and opinions of experts in energy management field, probable solutions are proposed to overcome the above barriers.

4.3. SUGGESTIONS TO OVERCOME IDENTIFIED BARRIERS

To overcome financial barriers, experts have given some practical suggestions. One of the suggestions is to reduce the equipment cost by reducing government tax levels. It was pointed out by Manager Mechanical and MVAC in case A as *"Solar panel price can reduce by reducing tax level on this solar panel and other equipment."* Not only that Maintenance Engineer in case B also suggested introducing a new loan system. As he indicated in his statement *"There should be loan system with the low interest rate for organizations to for this kind of projects, as most of organizations are suffering from the lack of financial initiatives and resources."* According to case analysis, less management commitment and support was identified as a major social barrier to adopt NZEB concept. To overcome this barrier, respondents suggested making the working environment more flexible where it gives a way to explain the situation to the management and to get their support. It is further proved by the Consultant Engineer in case C as *"So basically we have to explain as the technical manager to the finance manager and top managers about the short term and long term benefits of these energy management projects and should ask them to consider the present situation because, this the latest and energy saving solution. Further, maintaining energy saving building is important otherwise there is no profit from this building. In my idea technical team should get together and convince to them to implement energy saving methods in this*

building." Not only the Consultant Engineer, but also Project Manager in case A further reinforced it as *"If we can go ahead with the solar energy and thought the management, the gain is this much through this much of period. By convincing them we can go for next step. This is very practical if we can implement it then of course it will beneficial for the organization end to country."* According to the case analysis, converting existing building to adopt this concept was not identified as an economical option. To overcome this barrier, respondents proposed to adopt this concept since the design stage of buildings. This has clearly indicated by the Assistance Maintenance Engineer in case B as *"For commercial high rise buildings, it should be come from the design stage. It should be advised to the design team including architects at the design stage. Then the building can use maximally for the use of solar lighting, at least one side of building which has maximum sunlight can set for the solar panels, such things should be considered at the design stage."*

Accordingly, a framework is developed for implementing NZEB concept for reducing energy cost of commercial high-rise buildings in Sri Lanka by combining the key barriers identified and solutions proposed (refer Figure 4).

5. SUMMARY

Fulfilling total energy requirement is a major challenge today, especially in high rise buildings. Commercial buildings are a major energy consumer who has faced this vital challenge due to high energy demand. Accordingly, most of the organizations seek better options to fulfil their energy demand and to reduce their energy cost without generating serious threat to environment. Net-zero energy building concept has gaining momentum in this regard, as it contributes greatly to reduce energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources. However, the adoption of NZEB concept is a greater challenge, as most of the organizations have faced several issues to adopt this new concept. As the purpose of this study, the barriers to adopt the NZEB concept was determined through comprehensive literature survey and case studies conducted in three selected commercial high-rise buildings in Sri Lanka. Key barriers are identified as technical, financial, social, policy and legal related barriers to adopt the concept. High initial cost is a major barrier where less government and organizational policies, lack of space and lack of technology, etc. are also identified as key barriers to adopt NZEB concept. Accordingly, a framework is developed by proposing probable solutions to overcome the identified barriers. Reducing equipment cost, facilitating flexible working environment, introducing the concept at building design, national regulations for renewable energy generation, conducting awareness programs are some of the solutions proposed. Hence, the developed framework could be used as a firm base in both organisational and national levels to adopt Net Zero Energy Building concept to reduce energy cost of commercial buildings in Sri Lanka.

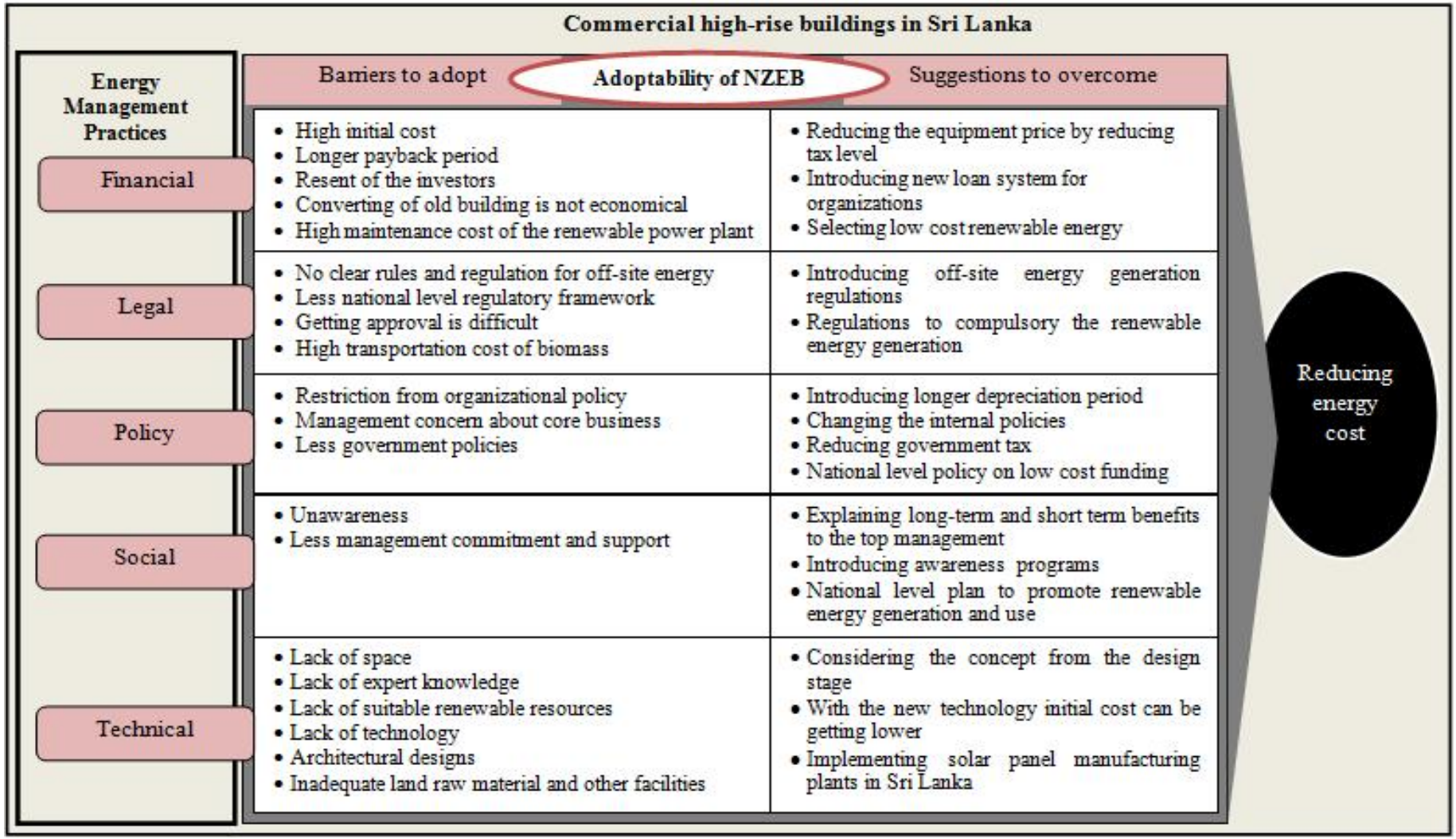

Figure 4: Framework to Adopt NZEB Concept

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