Examining Risk as Guideline in Design Stage for Green Retrofits Projects: A Review

M S N Lee, M A N Masrom, S Mohamed, KC Goh, N Sarpin and N Manap

Faculty of Technology and Business Management, Universiti Tun Hussein Onn Malaysia, Parit Raja, 84000 Johor, Malaysia
Corresponding author: zakimin@uthm.edu.my

Abstract. Green buildings have generally been adopted as strategy towards sustainable development to reduce greenhouse gas. The implementation of green concept recently has widely spread over the year. However, the positive impact to the environment is still low due to heavily focus on new construction project as compare with retrofitting the existing building. A retrofit practice is not only regaining overall existing building appearance, but the improvement towards energy efficiency is remarkably significant at the expense of huge challenges and risk. As a consequence, retrofit practitioner is confronting an assortment of risks at the early stage of the project. Given that, green retrofit concept is emerging research area to Malaysia construction industry which motivates to determining the risk involve in design stage. This paper aims to review risk in design stage for green retrofit project for commercial buildings through gathering comprehensive literature review. As a result, two main category risks in design stage (technical/quality risk and financial management risk) is determined and extracted to identify risk. These risks are then quantified through analysis to enhance design performance within cost-benefit. The proposed conceptual framework model is expected to assist retrofit practitioner to identify risk and obtain feasible retrofit strategy.

1. Introduction
Green buildings concept is primarily adopted as one of the effective strategies to protect the environmental in many countries [1]. Since construction industry contributes to significant impact to the environment, the introduction to green concept is evolving year by year. However, the greenhouse gas emission is still perceived although there is various practice of green concept available to use by construction sector. It is profoundly that the green concept is heavily focus on new construction project while to greening an existing building is relatively at low level especially in Malaysia [2]. The lifecycle of the existing building is starting to deficiency in operation phase and resulting large energy usage and poor performance of the building [3]. Therefore, green retrofit concept to the existing building is the best possible method to gain the sustainable practices by improving energy and environmental performance, reduce water use, improve the thermal comfort, and overall reduce the noise level [4]. Although green retrofit concept to the existing building improves energy efficiency and overall performance of the building, the principle to gain significant energy efficiency is facing huge uncertainty as the nature of workflow is totally different as compared to the new construction project. Thus retrofitting required systematically design strategy to obtain feasible energy efficiency. However, previous researcher has been focusing on post-retrofit but poor attention to the design risk which lead to the energy performance gap [5]. While, [6] stated that risk can influence the project cost, time & quality. Besides that, while government of Malaysia is committed towards promoting energy efficiency...
through building retrofit, there is limited study on the risk surround in design stage that will influence the final energy efficiency result. In order to fill the knowledge gap, this paper aims to review on risk involve in design stage for green retrofit project for commercial buildings in Malaysia. To accomplish this aim, the following question is addressed: What are the types of risk surround in design stage? What are the potential risks in design stage before proceeding into risk analysis? Therefore, a conceptual framework model is developed to assist stakeholders to understand the embedded risk in design risk that lead to energy performance gap.

2. Research Background
While green retrofit concepts are mostly implementing for developed countries, the study under developing countries is still on-going by most construction industry [7]. In Malaysia, the trend of building retrofit are slow-moving as there are various of uncertainties such as cost, expertise, and design strategies characteristic [8-9]. To date, there are only 24 retrofit project registered under Green Building Index (GBI) which shows the slow trend in the development of existing green building [10]. The design risk in retrofit is crucial to examine proactively and give huge impact to the environment, economic and social perspective [11-12].

A thorough understanding in design risk is ultimately would save project budget while maximizing the energy efficiency in the existing building. According to [13] the retrofit project is facing huge uncertainty compared to new construction project as the design information for existing building regarding specification, duration and cost is seems to be inaccurate. Similarly, the study by [4] show that the risks can be significantly higher if the project team such as architect, engineer and energy service company (ESCO) does not have enough capability in designing under green retrofit project. As consequences, poor retrofit design can lead to weaken energy performance throughout development of the energy model [5]. According to [12] the risk towards the development of green buildings has been identified seven categories which related to time, cost, quality, organization, policy, safety and environment.

Therefore, the previous literature review is primary focusing on the technical or quality risk in retrofit design. Next, the second part is further explored regarding financial management risk in retrofit design. Both literature reviews was conducted to examine the risk in design stage to obtain optimum retrofit design. The completion of the literature review is done by obtained through valid open-access sources database through Google scholar and Scopus journal database. The main keywords to find the related articles are ‘green retrofit risk’, ‘sustainable refurbishment risk’, ‘renovation risk’ and ‘design risk’. These keyword is used to narrow down the finding and the term retrofit and refurbishment is interchangeable. As a result, 30 articles were selected that highlight variables which contain significant findings to support the proposed conceptual framework model.

3. Risk in design stage: Technical / quality risks
Generally, the design in retrofitting involves technical and quality risk which consists of four high impact risks that directly influence the decision making in pre-construction stage. According to [14-15] the designer related to green building is essential to understand the principle of green technologies as how it integrate with building system. Similarly, study by [16] revealed the lack of knowledge by related stakeholder such as architect and engineer in green retrofitting design will eventually affecting energy-saving measures which consequently interrupt the decision making.

Through literature review by [17] highlights that lack of design experience will not only related to energy efficiency, but overall safety aspect of retrofit building. This can be seen from previous study which involve multi story Citigroup Center building retrofit safety as engineer in design is miscalculate the wind flow which is supposedly to use welded joint instead of bolt joint and end up structural failures. This is in line with the report by [18] concluded that lack of experience in design team participation will increase the risk of failure in retrofit project. Similarly, the studies by [19-20] indicate that the design strategies in retrofit can provide variation of energy savings result. From the final result in the studies revealed there are significant differences between low impact retrofit and deep retrofit impact in term of energy saving. A simple air leakage to improve moisture in design strategy for retrofit increase the chances of mold and potential of sick building syndrome [21]. There are tendency for retrofitted building
performance is below expectation due to uncertainty in design strategy since the theoretical energy
saving estimation based on material manufacturing references is not standardized by body of
professional accreditation [22]. Lack of standardization in design strategy for energy efficiency will
resulting high risk of building performance [23]. On the contrary, based on research analysis by [24],
the probabilities of occurrence for design experience risk towards green retrofit project in Sri Lan
da is high but does not giving much impact.

Furthermore, the low performance team is seeing reluctant to increase the risks during design stage
where it will influence the overall successful of green retrofit project. The contributions of several
different stakeholders with varieties set of knowledge and skills will determine on how it will bring
significant impact to overall retrofit project objectives [25]. The limited numbers of competent designer
will contribute to the design failure in retrofit thus giving an impact to the project cost in the future [26].
Similarly, [27] pointed out that competent project team in design stage such as architect and engineer
for retrofitting is necessary to form in based on experience. In addition, competent project team member
is needed by team leader to ensure the retrofit project possibly will improve by combination of wide
range of expertise throughout existing building in Singapore [28]. Therefore, to avoid possible defective
design risk, it is crucial for design team to understand what client need as stated in project brief as well
as establishing effective communication and collaboration in each project members to improve decision-
making process [29,30].

Moreover, maximizing the energy efficiency in retrofit project require innovation which is related to
the design knowledge and skills to draw a preliminary idea within project budget. According to [31,32]
highlighted that the material innovation is interrelationship with the cost as each of the selection in
retrofit option resulting different outcome to the energy and cost. The study concludes that replacing
appropriate material from aluminium to plastic in windows section resulting same energy efficiency but
with less cost. However, the availability of green technologies is presenting high impact in design stage
as a material might not available and importing from other sources would increase the cost [33,34]. As
pointed out by [35], the performance material of green technology is unknown and as a result, it might
effect the green requirement due to insufficient minimum standards set by local regulation [36].

Therefore, this shows that the combination of each risk in technical / quality will ultimately bring a
huge influence towards the project objective in order to achieve energy efficiency. Before commencing
design phase, it is essential for decision makers to follow a line of investigation to every aspect in design
stage to ensure feasible design can be achieved. Table 1 illustrates the summary each of the risk category
in technical/quality risk to examine the risk that has been identified from the previous recent study on
retrofit.

| Author | Risk category | Risk identified |
|--------|---------------|----------------|
| [15], [16], [17], [18], [19], [20], [21], [22] | Design experience risk | - Uncertainty in energy saving.  
- Lack of knowledge by consultant. |
| [24], [25], [26], [27], [28], [29] | Team performance risk | - Lack of knowledge and skill in retrofit.  
- Increase the unnecessary cost.  
- Lack of competencies.  
- Lack of communication and coordination. |
| [3], [14], [30], [31], [32], [33] | Material innovation risk | - Material is not available in local market.  
- Uncertainty in cost.  
- Uncertainty in material performance.  
- Low standard material |

4. Risk in design stage: Financial management risks
The combination of optimize design in green retrofit is greatly improving energy efficiency on existing
buildings but with the consideration in cost for each of retrofit option will influence the project budget.
According to [37] pointed that retrofit design need a reliable financial management so that the project
team especially for consultant to determine the right choice of retrofit option. A financial management in construction is related on how project team control the cost with considering of optimum quality and on time within budget allocate by the investor [38]. However, proper planning in financial management is vital as it may influence the design restriction over project budget [6].

Nevertheless, financial management risk in design stage surrounded by two important factors that contributing to the cost variance for retrofit project. In general, cost estimation risk in design stage involves uncertainty in term of cost-benefit over retrofit measures in existing building. In other word, the cost can be varied according to the design variation and since the objective to retrofit the building is to achieving energy efficiency in existing building, the risk is tends to increase the project budget due to failure in design [14, 35]). According to [37] highlighted that inaccurate cost estimation in pre-construction stage will lead to dispute after project is complete. Similarly, a cost estimating during planning stage is crucial for project team as it appear to be significant risk that contributing to the project budget [38].

For instance, a study by [23] revealed adopting green strategies in early stage for green retrofit project is essential to avoid design change that might increase project budget. The information exchange during design stage in green retrofit would consequently influence the quality of the project, thus the final result of the project will facing uncertainty in energy saving [15]. The alternative solution in design stage is evaluate based on economic perspective by project team since each alternative have an impact to the cost, lifecycle and value to the project [39]. However, the uncertainties in cost estimation are also influence by the current condition of the building as it will be too costly due to poor quality built on previous construction [40]. The cost involved in retrofit strategy is ultimately crucial to be planned in early stage to limiting the project cost beyond available budget [33]. Besides that, the cultural heritage building is limiting the retrofit option and alternative solution is needed to ensure the appearance of the building is protected [41]. In addition, the consideration of the country climates in design strategy is giving a great impact to the overall energy consumption since it contribute to the energy consumption such as warm or cold weather [42]. Therefore, the design teams are require to considering the characteristic of the building to ensure the design is accurate while avoiding risk of overrun in cost.

Apart from that, quality risk is appearing to raise an uncertainty toward design stage in retrofitting that reflects to the financial management in pre-construction stage. Since retrofitting for commercial building is normally deal with tenant operation, or even complicated if the project running in business hour, the consideration of these barrier need to be addressed to reduce tenant satisfaction while maintaining project time [43]. Besides that, using high quality product in designing retrofit project is often significantly improving energy efficiency in the long term. In addition, based on [23] revealed the quality risk is giving high impact and most likely influence to future cost in green retrofit project in Sri Lanka. Similarly, according to [4] pointed out the retrofit project will be no difference compared to conventional building project if the quality of energy saving does not meet the requirement in Green Mark Scheme in Singapore. For that reason, benchmarking tool for energy saving comparison is essential to compare each retrofit strategy to minimize design risk, hence increase the overall quality [44].

However, [45] argued through case study in LEEDBOM project where the simulation prediction of energy saving does not meet with the actual situation. Since the actual energy saving does not achieve as what in energy simulation tool plan, a quality in design stage is doubted and it is important for project team to evaluate before proceed to final decision in each retrofit strategies. In addition, throughout case study by [46] suggested that the consideration of inaccuracy factor in energy model is important to increase the confidence and enhance the quality of the design. Therefore, quality risk in design stage is significantly important to address by project team due to uncertainty in cost of the project. In overall, the identification of financial management risk is important to perceive optimum cost-benefit retrofit design. Table 2 illustrates the summary of risk that will be identified according to the previous recent study that vital to the construction industry to assess and control the risk.
Table 2. Summary of identified risk in financial management risk

| Authors     | Risk category        | Risk identified                                                                 |
|-------------|----------------------|---------------------------------------------------------------------------------|
| [23], [41], [32], [15], [39], [38], [40] | Cost estimation risk  | • Probability of design change.  
• Probability of information exchange.  
• Probability of cost overrun.  
• Various cost according to climate.  
• Poor current state of the building.  
• Limitation of design strategy for heritage building |
| [31], [42], [43], [44], [45] | Quality risk         | • Tenant operation.  
• Energy rating requirement.  
• Inaccurate of energy model. |

5. Conceptual framework model of risk in design stage

A definition of conceptual framework can be relate to the network that linked between each concept and grounded theory that presenting comprehensive information [46]. The combination from previous model developed by [48-49,6] can be adopted to present risk in design stage for green retrofit project to achieve target energy performance. The proposed conceptual framework was developed based on previous study as illustrates in figure 1. In overall, the early energy performance assessment can assessed through risk analysis either qualitative or quantitative technique to evaluate the risk. The qualitative analysis method defined as simple rating scale for risk but the evaluation result is vary according to the countries while quantitative analysis method is sophisticated technique which require time consuming [6]. Both analysis can be determined the feasible retrofit measure by quantifying risk to obtain optimum design while maintain cost-benefit of overall project [48-49].

Figure 1: Proposed conceptual framework model of risk in design stage

6. Conclusion

Green retrofit project is facing large uncertainties and risks as early in pre-construction stage. The risk surrounding retrofit project will lead to undetermined energy efficiency performance on existing building thus resulting high cost and low quality in a long term. In general, it is crucial to determine design risk in green retrofit as it possibly influencing cost, time and quality of the project. By considering the design risk in green retrofit project, it is expected that the risk that has been identified will enhance
the design strategy to achieve optimum energy efficiency. However, this study is limited to the internal risk in design stage and future study would expand to further investigate for external risk in design stage for green retrofit project. Nevertheless, due to huge challenges and risk in retrofit project in Malaysia, this study will assist construction industry to control the risk by taking an example from previous study on developed countries. Retrofit practitioner can modify each risk in design stage through proposed framework model to quantify which risk that need control to obtain optimum energy performance model. Throughout identifying risks towards pre-construction stage, it will therefore assist retrofit practitioners to respond and minimizing potential failure or error in design strategy for retrofit project.

7.0 References

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**Acknowledgement**
The author would like to thank Universiti Tun Hussein Onn Malaysia, Research Grant TIER 1, VOT H104 and GPPS, VOT H042, Research Management Centre Office UTHM, Department of Construction Management, and Faculty of Technology Management and Business for supporting this research.