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The Investigation of Energy Risk in Pre-Construction Stage: A Qualitative Approach

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Abstract

The energy demand growth every year for existing building due to the natural lifecycle of the building performance. Systematic strategy in retrofitting is proven to revamp the energy building performance. However, the retrofitting process is facing several of unknown risk as early in pre-construction stage to achieve optimum energy efficiency design strategy. The risk requires strategic assessment to minimize the impact towards the efficiency level in retrofitting. This study aims to examine the risks and the potential impact towards design strategies by conducting a semi-structured interview from six internal stakeholders in the retrofit project. The result derived from the interview revealed that there are 13 of major risks involve in retrofit project and divided into planning stage and design stage. All the risks are proven to provide a potential impact towards energy efficiency design strategies.

Keywords: Retrofit, existing building, retrofit risk, energy risk

■1.0 INTRODUCTION

Green building has generally been approved as one of the operative approaches towards achieving sustainable development through developed countries (Yu et al., 2011). Despite the fact that the introduction towards green concept in construction is dynamic, there are certain area need to be improved in sustainable concept to further support towards positive impact on the environment, specifically in existing building (Adeyemi et al., 2014). However, the sustainable development for existing buildings is evolving in recent years throughout the process of energy retrofit. Retrofits project modifies existing buildings to improve energy and environmental performance, reduce water use, improve thermal comfort, and reduce the noise level by applying new technologies (Hwang et al., 2015). The application of the new technologies in the existing building provides more variation to enhance energy efficiency in the existing building. Therefore, the application of new technologies on the existing building is constantly filled with uncertainty and risk (Lam et al., 2010). The process to achieve optimum energy efficiency level in existing building involves a huge of risks due to unforeseen condition occurred in the early phase of the project that will affect the post-construction phase (Bo & Chan, 2012). The existence of risk in the retrofit project provides challenges to each task as it allows for a different outcome in energy efficiency level by the combination of the planning and design stage (Janda & Topouzi, 2015). Risk can either be prevented or limit the probable effect on the energy retrofit design through addressing the risk (Zou et al., 2016). In Malaysia, the retrofit concept is circuitously put into practice in existing buildings, focusing on energy-efficient building design and achieving GBI rating. According to the National Energy Efficiency Action Plan drafted in 2014, the key initiatives to promote energy efficiency are building design that influences energy-efficient to the existing building (KeTTHA, 2015).

■2.0 RESEARCH BACKGROUND

Finding an optimal solution to increase the energy efficiency level on an existing building is the main criterion to achieve part of sustainable development (Basarir et al., 2012). As a growing set of findings is being provided, the need for advanced project management, energy management, technological capabilities management, and construction management in energy efficiency are valuable to the stakeholder required than ever before (Mohd-Rahim et al., 2017). Each of the requirements to fulfill the project objectives is facing various risks to meet the energy efficiency level. The risk associated with a project often reflects an adverse effect on the achievement and encounters unexpected problems despite all the precautions taken accordingly (Urbański et al., 2019). The evidence from previous case study showing that certain component from the retrofitting process are not performing as predicted which involves the risk in design stage (Ioannou & Itard, 2015).

Several other studies have also reported on similar performance difference when comparing the predicted and actual energy consumption of a building due to the risk. As a result, immediate action is necessary to address this issue in order to ensure that energy savings objectives are met and the sector receives the recognition it deserves (Alam et al., 2017). Several aspect contributing to the extension of risk is noticeable from previous scholar which reporting some unique constraint are exist as early stage in retrofitting (Zou et al., 2016). These constraints put the energy performance gap in retrofitting much more complicated to assess the risk without knowing the exact output from the project delivery. Thus, little research published by scholar that address the implication of the risk towards the energy performance in retrofitting during pre-construction stage. Additionally, there are several factors that need to be considered when determining the energy efficiency design strategies in retrofit project by addressing the risk. This study aims to investigate the risk that potentially impact on the energy efficiency design strategies by quantifying the exact and root cause that extend the energy performance gap in retrofit project. Therefore, addressing risk in a retrofit project is fundamentally critical to break the chain-reaction effect of the energy performance gap as early in pre-construction stage.

■3.0 LITERATURE REVIEW

In general, the green building concept is the fundamental to apply energy efficiency improvement related to the design and structure of the building (Kibert, 2016). However, the nature of construction on a green building are always exposed to the risk, especially in existing building project (Hwang et al., 2015). Retrofitting of existing buildings requires major planning in order to achieve successful retrofit project objectives. By considering the issues surrounding retrofitting works, each aspect of a retrofit is crucial since it involves existing buildings containing uncertainties that might affect the cost, time, and quality.

Generally, the achievement of retrofitting projects is depending on several aspects that might be considered by design team. Careful systematic planning provides a first barrier to minimize the risk as the uncertainties is highly develop from the early stage of the retrofit project. Ali (2014) stated the earlier risks are originated from the design stage due to unavailability or limited information and poor coordination in a project. The solid information is critical for the any upgrading building project which compulsory to allocate the availability, adequacy, accuracy, and consistency of the archival documents of the existing building during pre-construction stage (Ali et al., 2008). The coordination and knowledge among team members during the design stage is seen as one way forward to reduce the possible risk thorough identification of risks as well as the assessment of risks (Zou et al., 2016). Since the objective of the retrofit project is mainly to achieve energy performance, the strategy towards gaining optimum energy efficiency design is vital in planning and design stage. The reason for this circumstance is that the planning and design activities in pre-construction stage is the root of risk factors that may degrade the energy performance in retrofit project (Janda & Topouzi, 2015).

According to Frederiks et al. (2015), to improve the energy efficiency solution in existing buildings in planning stage, two major factors need to be considered, including public awareness and willingness to accept new technology used for a sustainable environment. Similarly, as highlighted by Krysiński et al. (2017), low awareness and insufficient knowledge towards energy efficiency technology are due to complicated technical systems that to be installed on their own. Zou et al. (2016) specified that retrofitting works are notably focusing on the various social aspects, specifically on public view and tenants' cooperation towards the building. Ma et al. (2012) highlighted the public view in retrofitting towards existing building would contribute to the loss of economic capital, poor tenant retention as well as downgrade the corporate identity. Poor preservation of knowledge throughout the investment required in retrofitting will compromising the performance aspect in retrofit building (Basarir et al., 2012). It is essential for decision-makers to find most viable retrofit solution within the most cost-effective way (Fan & Xia, 2018). A project team often to refusing to allocate the good retrofit design due to budget constraints which require a thorough design planning to avoid risk (Zou et al., 2016). Cha and Lee (2018) noted that inaccurate cost estimation in the pre-construction stage would lead to disputes after the project is complete. Similarly, cost estimating during the planning stage is crucial for the project team as it appears to be a significant risk contributing to the project budget (Ojo & Odediran, 2015).

■4.0 RESEARCH METHODOLOGY

Research methodology refers to the philosophies and actions of coherent thought processes which apply to a scientific exploration. Literature reviews were conducted to gain information on the existence of the risk in pre-construction stage for retrofit project. This study aims to investigate the risk that potentially impact on the energy efficiency design strategies with the internal stakeholder that are actively involved in retrofit project. Since there are low rate of expertise and professional retrofitting players exist in Malaysia, the series of face-to-face semi-structured interviews method were carried out to derive the existence of risk in pre-construction stage thoroughly. The resourceful information gain from the interview will brings the depth to understand and explore the scenario of risk handled by retrofit players specifically in Malaysia construction industry. The respondent has been selected in according to their area of expertise, highly experience (above 5 years), and knowledgeable in handling retrofit projects. This is to ensure that the respondent has adequate criteria to collect the valuable resources to find possible exploration on achieving research objective. Two organization are selected as the main population which derived from Energy Services Company (ESCO) and Architect that are actively involved in retrofit project. The data collection from six respondent obtained from the interview was saturated as the responses and the statements are almost the identical. This is also supported by Guest et al. (2006) which suggesting the guidelines through the evidence-based to determine the sample size in qualitative method as shown in Table 1. The interview session is audio recorded and the information is processed using Atlas.Ti version 9 through thematic analysis to translate the data into findings. The Transcription is coded, categorized and themed to answer the research objectives.

Table 1 Guidelines for determining the qualitative interview sample sizes (Guest et al., 2006)

Codes	Percent	Number of interviews in which the saturation achieved
80	73	6
100	92	12
8	100	13

■5.0 DATA ANALYSIS AND DISCUSSION

Based on the extraction from the data, the majority of the respondents participated in the interviews are experienced person. Table 2 indicates the respondent's participation according to their position, experience, education background and the type of organization. Six (6) respondents were interviewed from different companies which actively involved in retrofit project. The various involvement in retrofit project by the respondents are capable to provide resourceful information regarding risk in retrofit project for Malaysia scope.

Table 2 Details of respondents

Respondent	Position	Years of experience in retrofitting	Qualification	Organization
R1	Electrical engineer	9	Bachelor Degree	ESCO
R2	Electrical engineer	10	Bachelor Degree	ESCO
R3	Quantity surveyor	13	Bachelor Degree	ESCO
R4	Mechanical engineer	5	Bachelor Degree	ESCO
R5	Architect	6	Bachelor Degree	Architect
R6	Architect	12	Master Degree	Architect

Through the thematic analysis of the interview data, 13 sub-themes of risk factors have been identified. Table 3 and Table 4 show the identified risk factors themes according to each of the categories. The themes may present more than one category, which means that these themes can affect multiple phases of energy efficiency in the retrofitting project.

Table 3 Major findings of risk in planning stage

		Themes	Sub-themes (activities)
The risk towards energy retrofitting in pre-construction stage	**Planning stage**	Human participation in energy retrofit	User behavior interaction with the energy saving technology after retrofit; knowledge
		The poor demand in retrofitting	Complexity of the project create a gap of mutual trust with the retrofit consultancy
		Difficulties in determining return of investment over retrofit strategies	Complexity prediction of ROI and payback period; project cost; investment value
		Uncertainty of energy saving	Unpredictable climate change, variable energy policies, user various preferences and inaccuracy energy simulation base models
		Investment assessment	Price volatility among energy price and material; Funding incentive in retrofit for EPC
		Regulation limiting the retrofit intervention	Limited local green manufacturer with complying Malaysian Standard that incite the safety issues
		Investment support from the government	Limited supportive from funding assistance mechanism into small-medium size of energy services company
		Interference of law	Design exchange due to irregular requirement and regulation by local authority

Table 4 Major findings of risk in design stage

		Themes	Sub-themes (activities)
The risk towards energy retrofitting in pre-construction stage	Design stage	Design experience	Coordination between internal stakeholders; weather condition impact on the design strategy, the suitability of the design with current states of the building
		Limited expertise	Limited resource within skill and knowledge of the designer into retrofit industries
		Material standard	Non-standard material compromising energy efficiency and safety
		Investment over energy improvement	Over-spec design with non-economic cost on the project
		Accuracy of energy model from the building	Energy audit; user behavior pre-retrofit and post-retrofit; building capabilities and limitation

5.1 Risk in Planning Stage

This section highlights the results from the analysis concerning the current risk towards planning stage in retrofit project. Human participation in energy retrofit is part of a critical element to obtain optimum energy efficiency levels through the cooperation between pre-retrofit and post-retrofit. Indeed, the lack of interaction with the energy-saving technology would encourage more energy generated, thus increasing the risk of the energy efficiency gap in a retrofit project. The internal stakeholder, specifically for the design team, the characteristic of the user behavior is varied and subjective in every commercial building, which leads to the difficulty in determining the actual energy-saving usage. The user behavior attribute indicates that there are uncertainties in energy-saving, which require a comprehensive analysis regarding working operation hour, total building occupant as well as the other information related to knowledge in energy usage. According to Krysiński et al. (2017), low awareness and insufficient knowledge towards energy efficiency technology are due to complicated technical systems that to be installed on their own. In the planning stage, the establishment of energy surveying information regarding building occupants would be advantageous to the design team to collect and analyses the pattern of energy consumption. Similarly, Hwang et al. (2015) stated that the tenant cooperation is important at the planning stage as it will give significant implication on energy-saving goal after retrofitting works is complete. However, the additional commitment from facilities management during post-retrofit could educate a building user in energy saving to expedite the energy efficiency level and consequently assist the design team in achieving project objectives.

The next issue considered was the demand for the retrofit market currently low due to the complexity of the retrofit project to the client and the significant advantage gain from the design. The building capabilities and limitations in retrofitting works are the main concern for the design team to convince clients concerning energy efficiency levels in design strategies. The clarity of the working information is significantly assisting the project objectives among internal stakeholders during the early phase of the project to ensure the investment is worth the performance gain after the retrofit (Ali, 2014). This, therefore, the clarification information into the potential energy retrofit to the client revealed the importance of the knowledge and interest, which can shrink the demand risk of a retrofit project. Unclear project objectives will lead to project disputes and consequently breaking the mutual trust among internal stakeholders.

Complicated return of investment (ROI) is another issue addressed in the retrofit project as it involves a high cost to achieve optimum energy efficiency levels in the building. Each retrofit design has its own cost and certain payback period over energy saving throughout the life cycle. Moreover, Lee et al. (2014) asserted that retrofit project involves huge investment which posing an uncertainty in performance risk and contributing to the decision-making process during the planning stage. The retrofit team must seek alternative solution within limited resources to find an optimal energy efficiency design. Overspend on design intervention does not constantly reflect high achievable energy efficiency, which subsequently generates another investment risk. The volatile energy price trend into the upcoming future is unpredictable by internal stakeholders, thus forming inconsistencies in energy-saving and affecting the total of the payback period. There are also considerations on the effect of user behavior on how it can influence the building's efficiency level, which further establishes energy consistencies and payback period. Kontokosta (2016) stated that the long payback period will increase the difficulty by building owner in decision-making to retrofit.

The next risk revealed the uncertainty in energy saving from four critical points: weather, policy, user behavior, and the base model. It was found that the uncertainty of energy saving in the retrofit project brought them great attention during the planning phase of the retrofit project as the impact towards energy efficiency is significant. In the retrofit project, the consideration of weather is most likely the primary criteria to be evaluated due to the potential temperature outcome that may impact the building's thermal comfort. As the weather is difficult to predict, the building's energy efficiency inconsistencies are doubtful, resulting in a risk that needs to be assessed coherently during planning. According to Wei et al. (2014), the current energy efficiency model for retrofit is having a difficulty to predict the future energy saving due to volatility in energy pricing, climate changes, and environment of the operation. The design team have to undertake all the attributes and information to develop base models that predict an energy model. The energy simulation capability to predict energy saving is substantially dependent on the information gathered from the weather input and building occupant.

High investment in retrofit projects often poses an uncertainty of guaranteed energy saving in each design intervention. However, also, low investment in a retrofit project often reflects the little energy-saving outcome. A comprehensive investment assessment is needed to address a potential risk concerning energy efficiency. According to Tadeu et al. (2016), the full-cost investment in any retrofit technologies application does not reflect great performance, although it is significantly reduced in energy usage by sacrificing some cost. An unpredictable material cost and energy price in the future amplify more project investment risk. The differential outcome from prediction and actual energy saving puts even more high risk of the project investment, especially in Energy Performance Contract (EPC).

Cha and Lee (2018) asserted that inaccurate cost estimation in the pre-construction stage would lead to disputes after the project is complete. An investment assessment must determine viable strategies to highlight most techno-economic measures that fit with the resources. It is notable that the government's low fund assistance support is likely increasing the probability of poor investment in a retrofit project, consequently affecting optimum energy-saving solutions into the building. The guidance and support policies by the government will help green technology adoption to be a more straightforward process in retrofitting (Chan et al., 2018).

Another point raised concerns on irregular regulation into the retrofit project, highlighting the limited number of green technology manufacturers in Malaysia. The stringent policy into obtaining certified Malaysian Standard upon green material is limiting more selection of the retrofit technologies into the market, which in return, the potential of higher energy efficiency solution is turn out to be scarce. According to Dixon (2014), clear consistency of retrofit policies by providing standards, including approved products from a supplier, is needed to allow a retrofit player to have more certainty in choices of technology. The safety issues for not complying with the local authority regulation on uncertified retrofit technologies will lead to safety risks that may jeopardize building occupant life. The uncertified technology used in retrofit projects somewhat becomes a nominal threat and reveals a new dimension of risk, which prone a design team to consider illegitimate equipment as part of their design strategy. Uncertified technology is arguably not concerning purposely on safety issues, but the efficiency level output is also doubtful, hindering the optimum energy retrofit strategies in the building. Therefore, the green technology supplier's availability is remarkably critical in retrofit strategies to expand more selection of the design strategy while avoiding uncertified equipment that compromises safety and inefficient design strategy.

A low support mechanism towards supportive funding from the government into the retrofit project may influence the overall project objectives. The fund injection into the energy retrofit project shall provide efficient design strategy in the retrofit project, especially for small and medium sizes of Energy Services Company (ESCO). The retrofit project's complexity requires systematic analysis in the planning stage to optimize the cost-benefit, such mechanism allowing ESCO to provide an optimum energy-saving package through EPC contract and are able to compete with the conventional procurement. Similarly, Kuusk and Kalamees (2016) suggested that the policy in subsidizing energy retrofit is not worth for minor energy efficiency improvement, but financial support is needed for the deep retrofit in an existing building. Therefore, a complete guideline into an energy-saving investment for funding providers will grant a mutual trust in the retrofit project while minimizing the risk of underperforming energy efficiency.

The restriction of law under local authority guidelines put another barrier within the potential of retrofit strategies that shall be addressed accordingly by the architect. According to Thuvander et al. (2012), law and regulation would limiting the exploration on potential of energy efficiency to the existing building. Irregular building regulation will create further complexity in the design. The new plan requires new approval, which will consume additional time and cost due to the delay. A newly approved plan will provide a different energy efficiency strategy and broaden even more energy-saving gap. Although the strict requirement is implied under retrofitting for an existing building, it appears that the rational basis of those regulations is mostly for safety purposes as following under the Uniform Building By-Laws 1984 (UBBL) minimum requirement for construction activities. The design team needs to comply with the requirement to prevent additional costs while maintaining the energy efficiency objectives. The policies will help related stakeholders to implement retrofit more efficiently throughout the guideline and standardization produce by the government (Hwang et al., 2015).

5.2 Risk in Design Stage

The research revealed that each stakeholder's coordination is crucial to develop a quality retrofit project through optimum energy design strategy. In fact, the combination between architect and engineer into a design strategy shall provide a comprehensive, detailed output of the project information without any failure. The collaboration between stakeholders is indeed the best solution to identify the capabilities and limitations of each building. For instance, a lack of cooperation between stakeholders will cause a conflict in the design period and affect the retrofit project's energy efficiency strategy. The coordination and knowledge among stakeholder during the design stage seen as one way forward to reduce the possible risk from thorough identification of risks as well as the assessment of risks (Zou et al., 2016).

Other points raised concern about the lack of skill and knowledge in a retrofit project. A limited amount of energy retrofit expertise will hold a wide range of intelligent and creative energy retrofit solutions in the construction industries. An appearance of an innovative design strategy is valuable in the retrofit project and provides advantages to the energy efficiency level of the building. Similarly, Bertone et al. (2018) pointed out competent project team in the design stage, such as architect and engineer for retrofitting is necessary is critical to avoid defective design risk. Since the retrofit project imposed various risks, a true challenge appeared in minimizing the design error or failure that may compromise project objectives.

The usage of non-standardized material in the retrofit project was also part of the risk that may affect the building's overall energy efficiency level. The unknown specification and characteristic of the material fitted into the building will trigger safety concerns upon building occupants. Although the material cost is the main apprehension for the design team, the quality delivered from authorized material is often quality and accurate due to SIRIM standards' compliance. As pointed out by Durmus-Pedini and Ashuri (2010), the material of green technology poses a factual risk of underperformance due to the material is not tested and approved in energy-saving, resulting in uncertainty in energy performance during the design stage.

A true retrofit project involves complex design intervention within the most reasonable cost budget over energy-saving gain in the future. Therefore, the design strategy is opting for various technologies that provide a different kind of energy consumption and cost. For instance, the value provided in the propose design strategy poses different risk factors to evaluate whether the project's investment is significant, with the advantages achieved from energy saving. The essential energy audit assessment to minimize the potential of the project being over-invest is likely the only mechanism that can be presented a wide range of propose design strategies for the design team. Similarly, the design team are required to determine the cost effective measures to ensure the investment is worth with the energy-saving produce in the long run (Qin et al., 2016). Retrofit projects that are over-spec are potentially generating huge investment, which turns out to be pointless, whereas more other design solutions are more practical.

The retrofit project challenge lies behind the availability of the existing plan that holds a construction design and assigns each of the attributes into the energy audit. Every single data related to the energy pattern is important to ensure the innovative design strategies can increase energy saving and improve building occupant satisfaction. However, every building that plans to be retrofitted have different attributes, thus the accuracy to obtain different prediction value is ambiguous. Bozorgi and Jones (2013) suggested that the consideration of the inaccuracy factor in energy model is avoid risk in deficiencies design for retrofit project. For instance, maintaining the estimation throughout the simulation prediction-based energy model is another key apprehension since the uncertainty of energy saving is based on the user behavior pattern. The percentage of energy-saving from the prediction base model is arranged and designated into value to estimate the target range of energy consumption. The disparity between the predicted user behavior with the actual condition is relatively complex and significantly impacts the retrofit project's energy saving. Therefore, the risk of accuracy in the energy model brings an unpredictable value to energy consumption, hence refining it to achieve effective energy saving for time.

■6.0 CONCLUSION

All the risks exposed during the pre-construction stage deliver a crucial threat in achieving energy efficiency design strategies. A good retrofit project requires a dynamic approach in the early stage of the project to assess and evaluate a potential risk due to the complexity and uncertainty that involve a huge cost in design strategies. The common goal to attain high-performance retrofit building relies heavily on the information of the building condition that is valuable for internal stakeholders to explore the most optimum design strategies that are economical, efficient, safe, and comply with building requirements.

In the event of an unlikely threat of risk, the effect of underperforming to the building would appear significantly that may throw in a big loss to the building owner. This study has analyzed two different risk areas involved in the pre-construction stage, namely the planning stage and the design stage. From the result, it is confirmed that the risk in pre-construction stage for retrofit project has thirteen (13) risk factor that potentially impact towards energy efficiency design strategies. Given the potential risk factors that has been highlighted, the contribution from this study may assist retrofit key players in decision-making process during early stage of the project and creating solid energy efficiency design strategies to achieve optimum energy performance during operation stage. The future study shall cover the relationship between the retrofit element and each of the risk factors to examine the connection with achieving optimum energy efficiency solution for retrofitting.

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