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Implementing Energy Retrofits in Existing Hotel Buildings using In-House Teams: The Decision-making Process

Article

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Abstract

Purpose – Among the existing buildings, hotels use as much as 50% of their total expenses on energy and offer significant opportunities for Energy Efficiency (EE) improvement. Yet, comparatively the level of implementation of Energy Retrofits (ER) in hotels appear to be low. This has been mainly attributed, inter alia, to the absence of clearly defined process for ensuring the delivery of ER and lack of proactive guidance for project teams to make right decisions. Hence, this study aims to propose an effective decision-making process, which could support the successful adoption and implementation of in-house led ER projects in existing hotel buildings.

Design/methodology/approach – Two in-depth case studies were carried out focusing on ER projects led by in-house teams in existing hotel buildings. Data was collected via 14 semi-structured interviews and was analysed through code-based content analysis.

Findings – The decision-making process for ER projects led by in-house teams was developed, which presents 39 key activities to be performed and 16 key decisions to be made. The parties responsible for these identified actions and decisions as well as the points at which each decision should be made to ensure the success of ER projects was also identified.

Originality/value – Twenty-one new activities and ten decisions relevant for in-house team led ER decision-making processes previously not found in literature were identified. It is hoped that the decision-making process developed in this study will serve as a roadmap for the effective adoption and implementation of ER in existing hotel buildings.

Keywords – Case studies, Decision-making process, Energy Retrofits (ER), Existing buildings, Hotel buildings, In-house team.

Paper type Research paper

1 Introduction

Despite international level targets to double the global rate of improvement in Energy Efficiency (EE) by 2030, the current rate of progress towards achieving these targets seem to be well below the required pace (United Nations, 2016). Within this context, the enormous energy saving potential of the world's building stock, which consumes around 30-40% of the energy (Friege and Chappin, 2014), has often been highlighted.

As existing buildings account for the largest portion of the building stock (European Climate Foundation, 2013), enhancement of EE in existing buildings is crucial to attain a timely reduction in global energy usage (Ma et al., 2012). Herein, Energy Retrofits (ER) provide a useful way to improve the EE of high-energy-consumption buildings (Xu et al., 2015). ER includes all the alterations made to the existing building systems and equipment to improve the energy performance of buildings (Ashrafian et al., 2016).

Despite the significant room for EE improvement in existing buildings (Hendron, 2013) and numerous associated benefits (Hou et al., 2016), still there is comparatively low level of implementation of ER (Friege and Chappin, 2014; Liang et al., 2016). This has been attributed, inter alia, to the absence of a clearly defined process for ensuring the delivery of ER, lack of proactive guidance for project teams to ensure that they make the right decisions to achieve the desired EE outcomes (Gultekin et al., 2014), and conducting ER projects in an ad hoc basis without a systematic decision-making process (Hall, 2014). Hence, it appears that informed decision making is essential to enhance the successful implementation and propagate the benefits of retrofits (Swan and Brown, 2013). However, in terms of research, most of the attention so far has been focused on investigating the technological aspects of EE measures with little focus given towards exploring the 'soft' aspects of decision-making processes (Ruparathna et al., 2016). Furthermore, as ER projects may be implemented through in-house teams as well as outsourced to experienced Energy Service Companies (ESCO) (Ma et al., 2012; Xu and Chan, 2011), these decision processes themselves can vary. The aim of this paper, therefore, is to investigate the decision-making process and develop a suitable decision support tool that can be used during the decision-making process when implementing ER projects in existing buildings. Among the existing buildings, this study has limited its focus to hotel buildings. Hotel buildings, as a type of high energy-consuming large-scale buildings, offer much opportunity for EE improvement (Xu et al., 2012). In the Sri Lankan context as well, the hotel buildings spend as much as 50% of their total expenses on energy mainly due to their 'extended operation', and has been found to have around 20% saving potential (Sri Lanka Energy Managers Association, 2009). Furthermore, lack of personnel and internal expertise have been identified as the key reasons for many ER projects to remain unimplemented in existing hotel buildings (Xu and Chan, 2011). This further reinforce the need for developing a tool to facilitate the decision-making process of ER projects particularly when using in-house teams, which could assist practitioners to successfully undertake and execute a retrofit project.

2 Decision-making process of ER projects

Informed decision-making is vital for enhancing the energy performance of existing buildings (Ruparathna et al., 2016). According to Malatji et al. (2013), investment in ER projects made with the help of decision-making tools has the potential to attain large monetary savings. Similarly, Gultekin et al. (2014) highlights that providing a sound technical process for decision-making early in the ER process is useful to address the complexity of ER process. Hence, various systematic approaches for decision-making in ER projects have been suggested by different authors. However, many of these attempts (for e.g. Hendron, 2013, Ma et al., 2012, Syal et al., 2014) do not provide a comprehensive understanding of the whole retrofit process, which is necessary to make informed decisions on ER (Crilly et al., 2012).

Among the available processes, the one proposed by Ma et al. (2012) classifies the overall building retrofit process into five major stages: namely, project setup and pre-retrofit survey; building energy auditing and performance assessment; identify possible retrofit measures or options; site implementation and commissioning; and validation and verification. This appears to cover all the key stages and hence, provides a useful basis for understanding the decision-making process of ER projects in this study.

Hwang et al. (2015) have defined 'pre-retrofit' as the state prior to the implementation of a retrofit project and 'post-retrofit' as the state after the retrofit completion. Within this context, the five stages identified Ma et al. (2012) can be further categorised into three different phases as pre-retrofit (which includes project setup and pre-retrofit survey; building energy auditing and performance assessment; and identifying possible retrofit measures or options), retrofit implementation (which includes site implementation and commissioning) and post-retrofit (which includes validation and verification) phases.

Review of literature disclosed various decisions to be made and activities to be performed throughout each of these five stages (see Hendron, 2013; Liang et al., 2016; Ma et al., 2012; Mohammadpour et al., 2016). In the project setup stage, it is essential to decide 'whether to launch a retrofit project' and to continue to the next step of energy audit (Liang et al., 2016). During the building energy auditing and performance assessment stage, modification potential of the building is assessed and the decision of 'whether a building should be retrofitted or not' is made (Liang et al., 2016; Ma et al., 2012). Based upon the results of the building performance assessment and energy auditing, ER measures to make the building more energy efficient can be decided (Jafari and Valentin, 2017). Moreover, 'how much money to be spent on ER project' is another main decision to be made at this level (Jafari and Valentin, 2017). During the retrofit implementation stage, 'when and how ER should be implemented' may be decided, leading to site implementation and Testing and Commissioning (T&C) of the selected ER measures (Liang et al. 2016). Finally, during the validation and verification stage, the results from post-occupancy surveys and user/client feedback can be considered to decide 'what kind of modifications to be made' if any to the implemented systems (Hendron, 2013). Considering the aforementioned, the conceptual decision-making process for ER projects was developed as shown in Figure 1.

Figure 1. Conceptual decision-making process of ER projects

Despite the above, still there is no comprehensive process available identifying all the vital activities to be performed and the decisions to be made in an ER decision-making process with clear indication on the precise points at which each decision should be made. Furthermore, it is important to identify the parties responsible for performing such activities and making the decisions. Further, as Heo et al. (2012) note, the current methods are incapable of supporting ER decision-making at large scale. This in turn highlights the need for further development of the decision aid processes to assist less-experienced decision makers to approach decisions the same way as experts would (Kolokotsa et al., 2009).

When it comes to the hotel sector in particular, lack of time and personnel to design and plan the ER projects due to other priorities has been highlighted as a reason for the low rate of adoption of ER projects (Xu and Chan, 2011). Hence, developing a decision-making process for the adoption and implementation of ER projects in the hotel sector would facilitate the practitioners in effective adoption and implementation of ER projects. The remaining sections of this paper go on to present the research methods and findings from two case studies in hotel buildings to address this identified gap.

3 Research methods

The study uses a qualitative case study strategy which allows the investigation of a contemporary phenomenon within its real-life context (Yin, 2009). Two cases (Cases IH1 and IH2) were selected from existing hotel buildings that have completed ER projects led by in-house teams during the last five years and have received the Sri Lanka National Energy Efficiency Awards. ER projects can be categorised as shallow (i.e. adopting measures that are relatively easy to install and have low upfront cost), medium (i.e. focuses on individual systems to achieve the potential energy savings of each building system) and deep (i.e. focuses on multiple building systems and adopt an integrated design approach) retrofits (See Chunduri, 2014). Among these types of ER, the focus of this study was limited to shallow and medium retrofits only, since in practice hotel buildings rarely undertake deep retrofit projects due to their operation type. Case IH1 had prior experience of successfully executed ER projects in their facilities, whereas for Case IH2, this was the first retrofit project undertaken.

Altogether 14 semi-structured interviews were conducted for data collection. The respondents were selected to include the key stakeholders involved in the decision-making process of each ER project. Details of selected cases and respondents are presented in Table 1.

Table I. Details of the selected Cases and Respondents

Data analysis was done through code-based content analysis using QSR.NVivo (2011) computer software, to identify the activities and the decision points of the ER decision-making process. Findings from case study analysis are discussed in the subsequent section.

4 Case study analysis

Outcomes of the interviews revealed the decisions to be made and the activities to be performed throughout an in-house led ER project which could be fitted within the five stages of ER decision-making process identified through the literature review. Figure 2 presents this identified decision-making process including key decisions to be made by the respective parties (i.e. client/top management, FM, building services engineer, and QS/cost consultants), the key activities and the optional activities to be performed by the respective parties (i.e. Engineering/Facilities Management (FMgt) division and client/top management) during each stage. Further, the best practice activities identified from case studies which are considered as good to perform in each stage are also presented. In Figure 2, the first two stages of the decision-making process have been renamed as ‘project set-up’ stage and ‘building energy auditing’ stage due to the findings from the case studies, which are discussed in detail in section 5. The key findings are further discussed in the following sections.

Figure 2. Decision-making process of ER projects led by the in-house team

4.1 Pre-retrofit phase of ER projects

The pre-retrofit phase comprised of three main stages; i.e. ‘project set-up’, ‘building energy auditing’, and ‘identification of ER measures’.

The project set-up stage is the first stage of the decision-making process. This stage begins with the identification of the need of retrofitting and ends with pre-determining the parties to be involved (refer Figure 2).

In Case IH1, the need for retrofitting was identified when a performance assessment revealed some inefficiencies with respect to the energy consumption in the particular property. After identifying the need of retrofitting, 'their capability to undertake a retrofit project' was assessed in terms of financial stability and knowledge level of the employees. Based on these assessment results, the FM of the hotel had to decide 'whether to launch the retrofit project or not'. According to respondent IH1R2, '*if there is significant potential for saving, but no enough capability to proceed with a retrofit project, then we have to make another decision, that is to still proceed with the project by obtaining the assistance of an ESCO or drop the project'* (indicated by the 2nd decision point in Figure 2). If an organisation decides to obtain the assistance of an ESCO, the project in turn becomes an outsourced ER project, which generally follows a different decision-making process (refer Fasna and Gunatilake, 2019).

In Case IH2, the need of retrofitting was identified by the chief engineer of the hotel (i.e. FM) when monitoring and evaluating the energy consumption of the hotel over its past consumption data. Subsequently, he had decided to launch a retrofit project and had 'set the targets' based on his rough understanding of the hotel's saving potential. Afterwards, he had 'pre-determined the parties to be involved in the project along with rough idea on roles that should be assigned to each'.

Findings of the cross-case analysis revealed that, in both cases, the decision to launch a retrofit project is made when the need of retrofitting was realised. Among these two cases, Case IH2 did not assess their capability to undertake this project. As Case IH2 involved a shallow retrofit project, this may be due to their perception that it was a relatively simple undertaking. 'Pre-determining the parties to be involved in the project' along with their prospective roles is a unique activity performed by Case IH2 in this stage. This activity appears to be a novel activity elicited through the analysis and not disclosed in the existing literature (refer Figures 1 and 2).

Building energy auditing stage represents the activities associated with clearly identifying the saving potential of the facility and selecting the most suitable system(s) for retrofitting (refer Figure 2).

Case IH1 had conducted an in-depth audit in this stage and thereby, clearly identified the areas with saving potential reconfirming their decision for retrofitting. Then attempts had been made to convince the top management about the need of retrofitting who in turn had to decide 'whether to provide permission to proceed with the project or not'. Afterwards, Case IH1 had set targets for the project based on the audit results. This appeared to be contradicting with Case IH2 which had set targets for the project immediately after identifying the need of retrofitting.

Following this, the scope of work for the project was defined. Findings from Case IH1 disclosed that in this stage, FM had to decide the parties to be involved and their roles. Then along with the consultation of client/top management, the parties to be involved in the ER project along with their roles were determined. Afterwards, the most suitable system for retrofitting is selected by the FM, considering each system's level of energy efficiency and contribution to electricity cost as well as the amount of energy cost reduction and emission reduction that could be gained through retrofitting.

At this stage, an audit had been conducted in Case IH2 to determine the saving potential as well as to properly refine and modify the set targets, and thereby, to make the top management aware of the need of retrofitting. Then, the scope of work of the project was defined. Respondent IH2R1 affirmed that 'who were the parties to be involved and what were the roles to be performed' was a key decision to be made in this stage after defining the scope of work as it facilitates to avoid role ambiguity and ensures the proper execution of the tasks. Afterwards, the most suitable system for retrofitting had been selected similar to Case IH1 considering each systems energy efficiency level and contribution to electricity cost, the amount of energy cost reduction that could be gained through retrofitting, and the impact of each system's operation on guests' comfort.

In brief, it is clear that both cases have the practice of conducting in-depth audits to clearly identify the energy saving potential. Case IH1 had set targets for the project after getting the top management's approval to proceed with the project, while Case IH2 which had set targets in the project set-up stage, had refined and modified the set targets in this stage (refer Figure 2). 'Determining the parties to be involved in the ER project along with their roles' is an activity performed by both cases specifically after defining the scope of work of the project.

The selected two cases had determined the most suitable system for retrofitting by considering the level of efficiency of each system in terms energy consumption, each system's contribution to electricity cost, and amount of energy cost reduction that could be gained through retrofitting. In addition to above, Case IH1 had considered the amount of emission reduction that could be gained by retrofitting each system, whereas Case IH2 had considered the impact of each system's operation on guest comfort as well to determine the most suitable system for retrofitting.

Identification of ER measures is the third stage of ER decision-making process and involves identification of the most suitable ER measures and development of a plan for implementation (refer Figure 2).

After selecting the air-conditioning system as the most suitable system for retrofitting in Case IH1, the most suitable ER measure had then been selected mainly based on their past experience with similar projects without any proper assessment of possible ER measures. However, prior to finalising their decision regarding the most suitable retrofit measure, they had 'assessed the availability of needed resources (including the availability of technical knowledge and local know-how) to proceed with the implementation of the specific retrofit measures' and 'assessed the modification potential of the facility' (i.e. ability to proceed with this kind of replacement in this particular hotel). These were identified as good practices adopted by Case IH1 in pre-retrofit phase (refer Figure 2). Amongst these, the latter was emphasised by respondent IH1R2 as one of the key lessons learnt from this project.

Within this case, upon selecting the most suitable ER measure, a project proposal was developed and subsequently submitted to the top management for approval. As per the findings, 'how much money should be spent on the project' is another key decision to be made by Client/top management at this level. After getting the top management's approval for the project, 'the previously defined scope of work was refined and expanded' into a detailed scope of work. Afterwards, both FM and QS/Cost consultant had to decide 'how the needed funding should be obtained', for which they have 'identified and assessed the available options to finance the project' and finally 'decided the most suitable financing option'. Finally, a plan to properly proceed with the project implementation was developed.

Compared to Case IH1, in Case IH2, they had assessed the available retrofit measures based on different criteria, with the intention of identifying the most suitable retrofit measure(s). In Case IH2, they had then attempted to refine and expand previously defined scope of work immediately after the selection of most suitable retrofit measures (i.e. prior to the development of the project proposal). This is because, the chief engineer (i.e. FM) in Case IH2, who had been assigned by top management to oversee the project, had decided to make the top management aware of the project progress as well as wanted to obtain top management's input for the scope of work. Then, he had 'requested suppliers in the market to provide quotations' and then 'selected the most suitable supplier and placed the orders'.

Though Case IH1 had 'identified and assessed the available options to finance the project' and 'decided the most suitable financing option', Case IH2 had directly decided to internally fund the project without identifying and assessing the available financing options, as this was a shallow retrofit with low upfront cost. Although 'developing a plan to properly proceed with the project implementation' is a vital activity to be performed in this stage (refer Figure 2), only Case IH1 had drawn attention to develop such a plan. This portrays another good practice adopted by Case IH1 in the pre-retrofit phase.

4.2 Retrofit implementation phase of ER projects

The key stage falls under the retrofit implementation phase is the '**site implementation and commissioning**', where the selected ER measures are implemented and tested (refer Figure 2).

In this stage, Case IH1 had first 'assigned a leader to take care of the system implementation'. Then the FM had selected the most suitable supplier and ordered the needed equipment. In this case, there was a need to construct a new building to install the retrofitted system due to limitations with the modification potential of the existing property. As respondent IH1R4 mentioned, *as our hotel was very congested, it was not possible to do the installation of the retrofitted system in the existing building which led us to construct a new chiller room*. Furthermore, the particular nature of ER and limitations of the modification potential of the property meant that in Case IH1 several other unique activities such as 'getting the local authority clearances' and 'obtaining necessary licenses for system implementation' was necessary. Then, FM with the consultation of client/top management and building services engineer, had to decide 'when to begin with the implementation of the selected retrofit measure' and 'how to do the installations'. In this case, the lack of familiarity and experience of the in-house personnel with installing the selected ER measure had led to hiring of a third-party with expertise for system installation. Then, they had 'implemented the selected retrofit measure' and 'performed the T&C'. After the successful implementation and commissioning, Case IH1 had to 'obtain the needed license for the operation of system', which is another unique activity for this case.

In Case IH2, 'when to begin with the implementation' and 'how to do the installations' are the key decisions made by FM with the consultation of client/top management. Similar to Case IH1, Case IH2 was also faced with the lack of skills and experience of in-house employees in implementing the selected measures. Hence, prior to implementing the selected retrofit measures, they had worked with the equipment supplier to 'demonstrate the way of doing installations' to the employees.

Among these two cases, only Case IH1 had 'assigned a leader to take care of the system implementation'. This was mainly based on their realisation that the lack of project leadership was a key factor which hindered the successful execution of the activities in the pre-retrofit phase. Conversely, in Case IH2, assigning a separate leader was not needed in this stage as there was good leadership for the project from the inception. Though Case IH2 had selected the most suitable supplier and ordered the needed equipment in pre-retrofit phase, Case IH1 had performed this activity during this stage. This was useful in the latter case, as the required construction of a new building to house the system could take reasonable amount of time.

The results from both cases also highlighted the importance of hiring a specialist contractor or else providing training for the in-house employees by conducting demonstration programmes during system installation to tackle the lack of skills and experience of in-house personnel.

4.3 Post-retrofit phase of ER projects

Validation and verification is the key stage coming under the post-retrofit phase. This stage is aimed at assessing the level of savings from the ER project. The stage involves monitoring the operation condition of the retrofitted system and ends with formal closing of the project (refer Figure 2).

In Case IH1, a main reason for monitoring the operation condition of the retrofitted system was to minimise the potential complaints from the hotel occupants and staff due to the poor performance of the system. Then, Case IH1 had 'appointed employees (i.e. a dedicated team) to handle and operate the retrofitted system'. It was important for the FM to then decide 'whether any training should be provided' for this dedicated team of employees to effectively operate the system and if yes, 'what are the aspects to be covered under the training programme'. Then, Case IH1 had performed post Measurement and Verification (M&V) wherein the focus was given towards 'observing energy consumption patterns and keeping records' and 'reviewing the project results and determining the level of success'. 'Whether any alterations to be made to the retrofitted system' to enhance its performance is another decision made in the post-retrofit phase in Case IH1. Accordingly the FM of this case had 'identified the areas which need further improvement' considering the inputs from energy auditor. Additionally, in Case IH1, it was also important to determine 'what are the arrangements that should be made to ensure the continuous functioning of the retrofitted system'. For instance, in this case the continuous operation of the installed retrofit system (i.e. a boiler) was reliant upon the supply of cinnamon. Hence, it was necessary to consider the availability of cinnamon, and arrangements to ensure its continuous supply. Then, the retrofit report was developed including the key findings from the project.

Similar to Case IH1, Case IH2 had also monitored the operation condition of the retrofitted system in this stage. Then, in this case, the chief engineer had 'assigned staff (i.e. foreman) to be responsible for monitoring and recording the energy consumption data', which was found to be useful during the performance of post M&V. Afterwards, post M&V was performed by 'observing energy consumption patterns and keeping records' and 'reviewing the project results and determining the level of success'. Following this, Case IH2 had 'identified the areas which need further improvement'. This implies that 'whether any alterations to be made to the retrofitted system' to enhance its performance is a decision to be made after the performance of post M&V. Then, similar to Case IH1 a retrofit report had been developed including the key findings of the project, which was in turn reviewed by the client/owner of the facility.

The results revealed that both cases had 'monitored the operation condition of the retrofitted system' in post-retrofit phase. In Case IH1, engineer of the property had monitored the operation condition of the retrofitted system, whereas in Case IH2, the chief engineer of the facility had performed this task.

Among these two cases, Case IH2 had not provided any training to its employees to properly operate and maintain the retrofitted system, since their project was a shallow retrofit resulting in only minor alterations to the existing systems. However, the findings from Case IH1 highlighted the importance of providing training for employees, particularly when the retrofitting results in significant changes to the existing system.

To properly conduct the post M&V, both cases had performed certain activities in this stage like 'monitoring energy consumption patterns and kept records', 'reviewing the project results and determining the level of success', and then 'identifying the areas which need further improvement'. Findings further revealed that in the post-retrofit phase, selected cases had the practice of 'developing a retrofit report' incorporating the key project findings, which was in turn reviewed by the client/owner of the facility.

5 Discussion of the findings

Though in the existing literature performance of a pre-retrofit survey is highlighted prior to performing an in-depth audit (Ma et al., 2012; Sesana et al., 2016), this appeared unnecessary in both the case study organisations. According to Respondent IH1R7, '*if the organistion has the practice of routinely monitoring and assessing the operational condition of each building system, it may not be necessary to conduct a pre-retrofit survey*'. Hence, the 'project set-up and pre-retrofit survey' stage ascertained through the literature is reworded in this study as 'project set-up' stage (refer Figures 1 and 2).

As presented in Figure 1, 'defining the scope of work' is identified as an activity to be performed in 'project set up and pre-retrofit survey' stage (Ma et al., 2012). However, in practice, the selected cases had defined their scope of work in the 'building energy auditing' stage. Although 'setting targets' is a crucial activity to be performed in the pre-retrofit phase (Mohammadpour et al., 2016), in these two cases this had been carried out at different points in time (e.g. in Case IH1 targets were set based on audit results while in Case IH2 targets were set after identifying the need for retrofitting and subsequently refined and modified based on audit findings). However, both cases had set targets before deciding on the most suitable retrofit measures as suggested by Mohammadpour et al. (2016). Further, according to Ma et al. (2012), the appropriate energy audit level for a particular project should be selected based on defined project targets. However, only Case IH2 had set the targets before conducting the audit which had in turn provided them good insight into the systems that should be focused during the audit. On the other hand, Case IH1 had set the targets based on the audit results. So, it is possible to deduce that Case IH2 had adopted a good practice in terms of setting targets which is in line with the literature.

As per Ma et al. (2012), it is also important to 'determine available resources to frame the budget and programme of work' during the project set-up and pre-retrofit survey stage (refer Figure 1). Even though, none of the respondents explicitly mentioned this as an activity, it was found that in Case IH1, after identifying the need of retrofitting, they had 'assessed their capability to undertake a retrofit project' in terms of financial stability and level of knowledge of employees. Further, in Case IH1 after assessing all the possible retrofit measures, they had also assessed 'the availability of needed resources to proceed with the implementation of the specific retrofit measures'.

Hendron (2013) disclosed that a preliminary analysis before the actual audit will show a building's current energy use and cost relative to similar buildings and will indicate the overall potential for improvement (refer Figure 1). However, the two selected cases had only performed in-depth audits as shown in Figure 2. This might be due to the reason that these two cases are planned and executed by in-house staff who may already have a rough understanding of the energy saving potential of the facility.

Building performance assessment is identified in literature as a main activity to be performed in 'building energy auditing and performance assessment' stage (Ma et al., 2012). However, it was found that both case study organisations had the practice of conducting building performance assessment on a routine basis through which the need of retrofitting can be identified. In addition, each organisation had re-assessed their energy performance during the energy audit. As respondent IH1R5 highlighted, in most of the instances the inefficiencies are recognised based upon their own internal assessments and they would then conduct an in-depth study (including an audit) to clearly identify the saving potential and decide whether to undertake the ER project. Thus, in this study the second stage of the ER decision-making process is rephrased as 'building energy auditing stage'.

As shown in Figure 1, 'assessing the modification potential of the facility' prior to the identification of possible ER measures has been highlighted by authors like Kumbaroğlu and Madlener (2012) and Ma et al. (2012). However, in Case IH1 'the modification potential of the facility' was assessed only after assessing all the possible retrofit measures. Since not all ER measures are equally effective, effective retrofit design requires extensive analysis of the alternatives (Ruparathna et al., 2016). Further according to Gultekin et al. (2014), 'determining the criteria and factors that should be considered' is one of the key activities to be performed to select the most suitable retrofit measure. However, the findings revealed that the two selected cases had considered different types of criteria/aspects while assessing the retrofit measures. Thus, it is possible to infer that 'determining the criteria and factors that should be considered' to derive the most suitable retrofit measure need not to be performed as a separate activity, rather it could be determined while assessing the different retrofit measures.

Ma et al. (2012) explains that after assessment, the retrofit alternatives can be prioritised based on relevant energy-related and non-energy-related factors to facilitate the selection of most suitable ER measures. Though, in practice this activity had not been done by these two selected cases, respondent IH2R1 noted that prioritising the ER measures based on attainable energy savings, feasibility of implementation, and payback period would be useful in deriving the most suitable ER measures. After deciding the most appropriate ER measures, an action plan needs to be developed to notify the client about such selected package of measures (Ma et al., 2012). Similarly, both cases had developed a project proposal after selecting the most suitable ER measures to make the client aware of the selected measures. Besides, 'developing a plan to properly proceed with project implementation' was another activity performed in Case IH1 during the 'identification of ER measures' stage (refer Figure 2).

As highlighted by Xu and Chan (2011), in the implementation phase, both cases had realised their lack of personnel and internal expertise to proceed with the implementation. To overcome this issue, Case IH1 had 'hired a third-party expert for system installation' while Case IH2 had 'demonstrated the way of doing installations' to its employees with the support of equipment supplier.

Review of literature disclosed that the main activities to be performed in the implementation phase are 'site implementation' and 'T&C' (Ma et al., 2012). Similarly, all the respondents attached to both cases had asserted the criticality of these two activities in the implementation phase. After the successful implementation of ER measures, standard M&V methods should be used to verify energy savings (Ma et al., 2012). Similarly, findings revealed that both cases had conducted post M&V by 'observing energy consumption patterns and keeping records' and then 'reviewing project results and determining the level of success'.

As has been highlighted by Panthi et al. (2017), during the M&V (specifically while reviewing the project results), both cases had focused on 'identifying the areas which need further improvement' (refer Figure 2). Additionally, these two cases had also paid attention towards ‘determining the arrangements to be made to ensure the continuous functioning of the retrofitted system’ which had not been highlighted in the literature.

According to Ma et al. (2012), performance of a post occupancy survey in the post-retrofit phase is essential to understand whether the building occupants and building owners are satisfied with the overall retrofit result. Though this was not practiced in either case, the respondents IH1R2, IH1R4 and IH2R4 all identified this as ‘*a very good practice*’, which is good to have in the post-retrofit phase. After conducting the post occupancy survey, it is essential to document and report the findings related to the implemented retrofits which should be reviewed by the client (Ma et al., 2012). Similarly, in both cases a ‘retrofit report’ had been developed, incorporating the key findings of the project which was then reviewed by the GM or top management of the respective facilities.

As a whole, through the case study findings twenty-one new activities relevant for the in-house team led ER decision-making processes were identified (refer Figures 1 and 2). These have been highlighted in Figure 2. Further in addition to the decisions identified from literature under each stage of the ER decision-making process, the case study findings revealed ten more decisions along with their precise decision-making points (refer Figure 2).

6 Conclusions

Aim of this study was to develop a suitable decision support tool that can be used during the decision-making process when implementing ER projects in existing hotels using in-house teams. Through two qualitative case studies, the decision-making process for ER projects led by in-house teams was developed, which presents 39 key activities to be performed and 16 key decisions to be made to assure successful adoption and implementation of ER projects. The developed decision-making process further indicates the parties responsible for these identified actions and decisions as well. Findings revealed that both ER projects followed similar processes with a few differences in the activities performed and decisions made, which can be attributed to the type of retrofit (i.e. shallow vs. medium retrofit) and the organisation’s past experience with ER. Thus, it is possible to infer that the process adopted by the organisations to retrofit their facility in the in-house led scenario, differs depending on project type and organisation’s past experience with energy retrofitting.

As a whole, this research has made a valuable contribution to knowledge by eliciting an approach that should be adopted by hotel clients to adopt and implement ER projects mainly when they are led by an in-house team. This in turn will provide a “frame of reference” with which current practices with respect to ER can be re-positioned.

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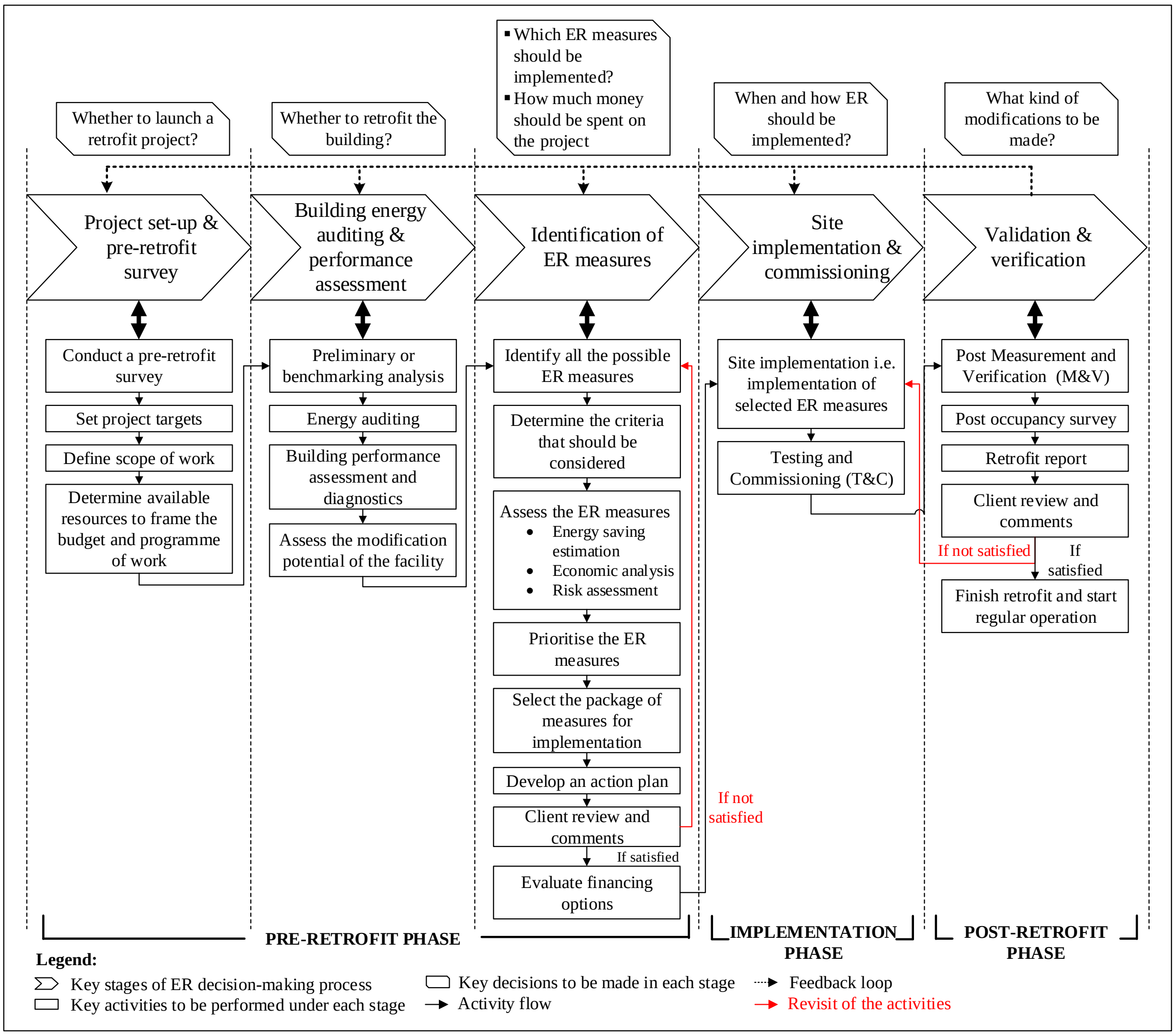

Figure 3~~1~~. Conceptual decision-making process of ER projects

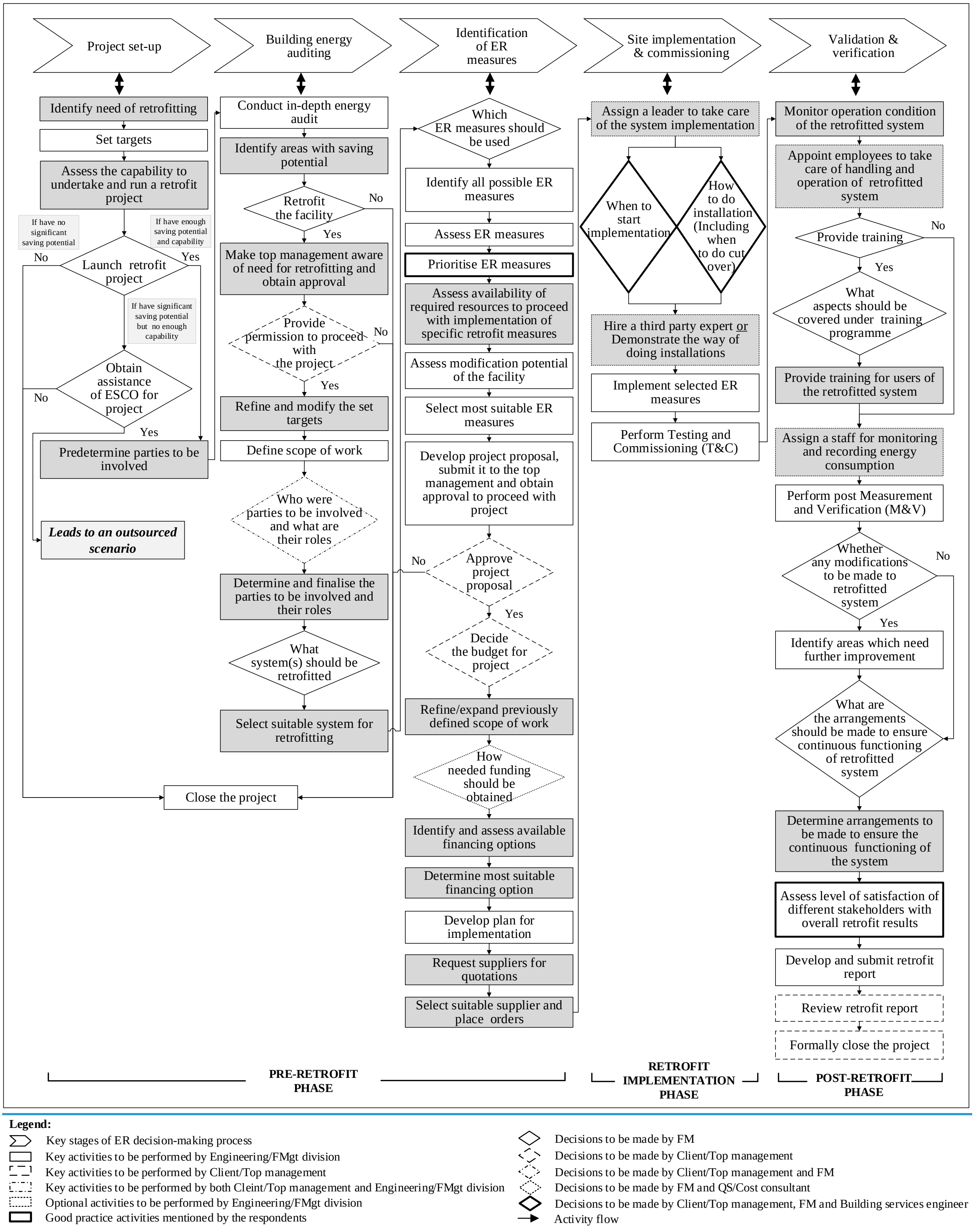

Figure 42. Decision-making process of ER projects led by the in-house team

Table III. Details of the selected Cases and Respondents

Case	Type of retrofit	Respondent code	Profile of the respondent	Roles played	Years of experience
IH1	Medium retrofits	IH1R1	Director General Manager of the particular hotel	Owner/Client	42
		IH1R2	Manager – Engineering of the hotel group	Facilities Manager (FM)	12
		IH1R3	Chief Engineer of the particular hotel	Facilities Manager (in implementation & post-retrofit phases)	41
		IH1R4	Engineer of the particular hotel	Building Services Engineer	16
		IH1R5	Engineer attached to another hotel in the particular hotel group	Energy Auditor	14
		IH1R6	Assistant Manager	Specialist Contractor, Supplier, and Architect	07
		IH1R7	Chief technical advisor – energy	Financial Institution	27
IH2	Shallow retrofits	IH2R1	Chief Engineer	FM, Energy Auditor	32
		IH2R2	Senior Foreman	Electrical Engineer	38
		IH2R3	Foreman	Electrical Engineer	17
		IH2R4	Cost Controller	QS/Cost Consultant	10