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Journal:	*International Journal of Building Pathology and Adaptation*
Manuscript ID	IJBPA-04-2024-0075.R2
Manuscript Type:	Original Article
Keywords:	Refurbishment, Building Performance, Risk, Stakeholders, Services

BUILDING PERFORMANCE IN REFURBISHMENT PROJECTS: A HYBRID FRAMEWORK FOR HOLISTIC PERFORMANCE DELIVERY

ABSTRACT

Purpose: Refurbishment projects are recognised as complex in nature, as they embed a high number of uncertainties and risks. One of the optimum aims in a refurbishment project is ensuring that performance is holistically and systematically accounted for. Although many studies have attempted to focus performance, limited studies have focused on the process followed or complexities encountered. This paper aims to provide an improved mechanism that support building performance accountancy for refurbishment projects.

Design/Methodology/approach: Data has been attained using secondary data from the literature and primary data using semi-structured interviews. The secondary data supported identifying building performance attributes for refurbishment projects whereas the primary data was obtained from 2 building surveyors, 2 quantity surveyors, an architect and an MEP Engineer who are involved in managing performance when executing refurbishment projects.

Findings: The findings show that refurbishment projects are primarily managed in the same way as new-build projects, which can be one of the major issues that cause many pitfalls as the project progresses. Analysis revealed that there is a lack of coordination between stakeholders and relevant data/information, which cause poor consideration of performance indicators. Analysis also showed that there is a lack of standardised approach to follow for refurbishment projects, which lead to poor performance considerations.

Originality: This paper presents a novel hybrid framework designed to proactively enhance building performance in refurbishment projects. By addressing the unique complexities and data requirements of existing structures, this framework aims to drive both immediate performance improvements and long-term optimisation.

Keywords: Refurbishment, Building Performance, Risk, Stakeholders, Services

INTRODUCTION

Building refurbishment is attracting increasing scholarly and practitioner attention within the construction industry, particularly in view of the increasing requirement to balance the competing requirements of the built and natural environments (Nutkiewicz et al., 2021; Luddeni et al., 2016). The target set by the UK government to achieve net zero by 2050 has contributed to shifting focus towards refurbishing existing building stock. The management of refurbishment projects can be challenging, this is largely due to the uncertainty factors that are inherent within building refurbishment and the presence of unforeseen elements which require a more flexible approach compared to new build developments (Yacob *et al*., 2019).

The uncertain nature of building refurbishment often creates further challenges when monitoring and managing project performance and is yet to be conceptualised for building refurbishment (Ranasinghe *et al*., 2021). According to Ishak (2018), the performance criteria for refurbishment projects is much broader due to the complex and multi-dimensional properties which encompass many factors. The integration of digital technologies such as Building Information Modelling (BIM) is growing for new construction, however it is not widely used for refurbishment projects. Many studies depict the processes and mechanisms used to manage project performance; however, the management of refurbishment projects has not been addressed properly in existing research (Kemer and Koskela, 2012).

The research addresses the apparent knowledge deficit when understanding the processes and techniques used to manage performance on refurbishment projects. Despite the degree of complexity associated with refurbishment there is a lack of systematic approach to manage the

level of uncertainty that is commonly associated with building refurbishment (Bocaneala et al., 2024). Often traditional mechanisms are adopted to drive performance however this a need to understand the challenges faced from industry professionals to provide a more tangible approach. This research aims to provide an improved mechanism that support building performance accountancy for refurbishment projects.

Refurbishment Projects: An Overview

Building refurbishment work can be defined as "*extending the useful life of existing buildings through the adaptation of their basic forms to provide a new or updated version of the original structure*" (Riley and Cotgrave, 2011, p.5). The extent of work can range from fit-out to a complete reconstruction and the scale, type and level of details of refurbishment are hugely variable (Sunil Shah, 2012; Shahi, 2020; Ranasinghe *et al*., 2021). The refurbishment and upgrading of existing buildings are a major contribution to the UK construction industry and account for just under half of the construction industry's total output (Gorse and Highfield, 2009). In recent years, the construction industry has seen an increase in the number of refurbishment projects. This is largely due to environmental and sustainability factors to improve the energy performance of existing buildings and utilise existing stock to meet changing requirements of building users. The recent target set by the UK Government in achieving net zero by 2050 will require the industry to focus on refurbishment of existing stock in order to achieve sustainable targets. It is estimated that 75% of the buildings of the year 2050 already exist now (UK Green Building Council, 2021). This demonstrates the importance of

Refurbishment projects are considered to be high risk compared to new build projects as they require the project team to work within the constraints of an existing building (van Leeuwen *et al*., 2000; Premachandra *et al*., 2020). Problems can arise when architects and designers start to develop the design based on incorrect or incomplete information. Unlike new build construction the design must be aligned with the existing building characteristics and specifications to ensure compatibility. Within the AECO sector, often prevailing industry standard and readily commercially available products are utilised on new build projects as typically these products are catered towards new-build and modifications are required to adapt to refurbishment projects (Lee *et al*., 2005; Noori and Mokariantabari, 2019). There is an additional level of uncertainty and variability as the extent of the work is not known until the strip out works have commenced. Information relating to the existing buildings such as "*reports, as-built drawings and manuals are not properly documented, incomplete or missing*" (Clancy, 1995). In many cases, data can be inaccurate due to changes or modifications made throughout the lifecycle of the building (Ali, 2010).

Refurbishment projects are primarily site driven and require site surveys to be conducted to gain an insight into the existing building (Egbu, 2010). This can be particularly problematic when assessing services within the existing building as the condition of services can be difficult to ascertain. In a study conducted by McKim *et al*. (2000), concealed services such as piping, or ductwork embedded in wall or ceiling voids and inaccurate drawings were major elements of un-foreseen site conditions resulting in cost and time overruns. Information relating to the services, structural properties and installed systems is critical, especially in older buildings (Mokariantabari, 2019; Yacob *et al*., 2019; Okakpu *et al*., 2020). Often quantity surveyors will include large provisional sums due to the lack of information at the design stage which can lead to a large number of costly variations during the construction phase.

Building Performance for Refurbishment Projects

Performance management is defined as "*the process of determining how successful organisations or individuals have been in attaining their objectives*" (Evangelidis, 1992, p.2). In refurbishment, it sets performance targets, prioritises resources, and aligns policies with project goals. Performance measurement, in contrast, identifies outcomes rather than causes and aids benchmarking and strategic monitoring (Stopps et al., 2021; Sezer, 2016; Demirkesen & Ozorhon, 2017). Effective performance management facilitates continuous monitoring, highlights inefficiencies, and supports informed decision-making (Costa et al., 2000; Alarcon et al., 2000; Oppong et al., 2017). Organisations lacking structured performance measurement often face lower-than-expected improvements and dissatisfaction (Longenecker & Finch, 2001, p.4).

While performance measurement is well-established, its application remains centred on new-builds rather than refurbishment (Ishak et al., 2018). With increased attention on refurbishment in the Architecture, Engineering, Construction, and Owner-operated (AECO) sector, tailored performance management approaches are needed. Traditionally, time, cost, and quality have been the main performance indicators. However, McKim et al. (2000) found that refurbishment projects face greater schedule and cost overruns than new builds due to ambiguous production information and fragmented work packages (Bryde, 2012). Furthermore, existing buildings often fail to meet client, user, or facilities management requirements, which differ significantly across stakeholders (Bortolini & Forcada, 2018; Shahi et al., 2020).

Refurbishment presents unique performance challenges, requiring integration of new systems within existing infrastructure while addressing operational constraints, safety, and structural limitations (Krizek et al., 1996; McKim et al., 2002; Singh, 2007). Unlike new builds, refurbishment requires extensive knowledge of existing structures to define appropriate performance parameters. Despite these complexities, AECO research disproportionately favours new builds, leaving refurbishment performance underexplored. The lack of structured research has led to reliance on traditional performance management approaches, despite their limitations (Ali & Au-Yong, 2021). A bibliometric analysis was conducted to highlight these gaps, demonstrating the need for more targeted refurbishment performance frameworks.

<Insert Figure 1 about here>

Figure 1 shows that most of the studies are inclined toward performance attributes related to energy. Although the focus on energy and its related attributes is significant and form one of the main focuses in a refurbishment project, other attributes such as indoor air quality, ventilation, durability and asset management can play a major part in the long term which can impact performance of the building (Bocaneala et al., 2024; Ali et al., 2018; Mayouf, 2016). This can support the need to gain perceptions into what considerations are taken into account when undergoing a refurbishment projects, and how these considerations are lined against different performance attributes.

Complexity of performance accountancy for Refurbishment Projects

Unlike new build projects, refurbishment requires co-ordination between the project team and the users of the existing building such as facilities or building managers (Seki *et al*., 2020). Evidence suggests that engaging building users is an essential element in the planning and control of refurbishment projects (McKim *et al*., 2000). Arguably, the process is seen as fragmented and relies on co-ordination of stakeholders to provide an integrated and flexible

approach (Ali and Au-Yong, 2021; Ali *et al*., 2013). The lack of research in the planning and management of refurbishment projects means that construction firms are relying on traditional practices whereby "*planning is centralised*" and "*communication between planning and production is carried out in a one-way fashion*" (Kemmer, 2018, p.14).

These management techniques are not equipped to deal with the complexities faced during a refurbishment project such as incomplete designs, site conditions, existing services, space constraints etc. It is widely known across the construction industry that standardisation can lead to reduced costs and improved quality. In a study conducted by Singh (2007) examining contractors involved in refurbishment projects, it was found that "*no formal documentation or standardised process was identified for dealing with the constraints intrinsic to such projects*" (Kemmer, 2018, p.36). In fact, one of the major complexities that impact the success of refurbishment projects is the lack of data availability (Bocaneala et al., 2024; Walker et al., 2022). According to many studies (e.g. Ali and Au-Yong, 2021; Ranasinghe et al., 2021), refurbishment projects are impacted by building shell, openings such as doors and windows, and MEP (Mechanical, Electrical and Plumbing) installations. The below table illustrates the different parts that impact refurbishment projects, their respective components, and overall impact on building performance.

<Insert Table 1 about here>

It can be stated that there are many inherent uncertainties in refurbishment projects, which can primarily be attributed to data availability, unknown risks that can be present at different stages in the refurbishment process, and the need to incorporate different stakeholders' needs and requirements (Ali and Au-Yong, 2021; Ranasinghe et al., 2021; Okakpu et al., 2020). More importantly, it is important to acknowledge that advanced technologies such as BIM, whilst provided more flexible and data-centric approach (Daultebek and Zhou, 2022; Veselka et al., 2020), their use in refurbishment context is considerably limited, and often the focus is on energy performance rather than overall performance (Bocaneala et al., 2024). Referring back to table 1, it is evidence that different building parts have an impact on performance, hence this research seeks to explore the complexities associated with the process of refurbishment and holistically attempts to provide an improved accountancy for building performance in refurbishment projects.

RESEARCH METHODOLOGY

This research enhances performance accountability in refurbishment projects by proposing a framework grounded in interpretivist philosophy, widely adopted in built environment research (Fellows & Liu, 2015). Inductive reasoning was used to develop theory from observed patterns, integrating deductive elements to refine theoretical and practical insights (Lloyd, 2017). Inductive approaches have proven effective in sustainability research (Goel et al., 2019) and qualitative data analysis, ensuring credibility and transparency (Kyngäs, 2020; O'Kane et al., 2019).

Primary data was gathered through six semi-structured interviews to explore performance management challenges in refurbishment. Participants included two quantity surveyors, two building surveyors, an architect, and an MEP engineer, ensuring diverse representation of key refurbishment stakeholders. To ensure practical relevance, all participants had experience in at least two refurbishment projects. The selection of experts was critical, as seen in Ali et al. (2018), where 55 survey responses were used to examine cost complexities in refurbishment

projects. However, the specialist nature of refurbishment projects makes expert recruitment challenging, justifying the smaller, targeted sample. Semi-structured interviews provided topic flexibility, capturing in-depth perspectives on refurbishment complexities and performance management.

Thematic analysis, widely used in management research (Braun & Clarke, 2017), was applied to examine participant experiences and identify patterns across responses. To enhance data validity, a focus group with the same participants was conducted, reinforcing findings and supporting framework development. Although based on a small sample across four professions, the proposed framework provides a foundational understanding of refurbishment challenges. Future studies should broaden its applicability by expanding the sample size and incorporating additional professional roles. This iterative framework serves as a prototype, with potential for further refinement to bridge theoretical and practical aspects of refurbishment performance management.

RESULTS

Three main themes were identified from the qualitative data, namely: i) existing conditions; ii) Methods/Processes used to deal with complexities; and iii) Complexities faced during Completion.

Existing Conditions

This theme highlights the complexities within existing buildings and their impact on refurbishment performance. All five participants identified unknown building elements as the main contributor to refurbishment complexities. One participant stated:

> "*The biggest complexity is the unknowns… assumptions are made, but once on site, intrusive work often reveals non-traditional construction methods. Information isn't updated when changes occur, so additional surveys are needed to understand the existing building.*"

Participants also emphasised that a lack of accurate information, particularly in surveys, exacerbates project challenges. All agreed that detailed condition surveys are critical. One participant stated:

> "*An accurate survey is crucial not just dimensions but structural, mechanical, asbestos reports, and historical site information*." "*Detailed surveys and validation reports backed by photographs are essential*."

These responses underscore the role of condition surveys as key data sources for refurbishment projects. Many participants also pointed out asbestos as a significant issue.

> "*Deciding whether to remove or encapsulate asbestos is a major challenge*."

Another added:

> "*Without an asbestos register, surveys must be conducted, adding time and cost. Information isn't always recorded properly in O&M manuals, which affects programming and pricing.*"

This suggests that incomplete asbestos records can lead to unplanned costs and delays, with risks often only uncovered once work begins. Besides information availability and potential asbestos issues, participants also identified regulatory challenges in refurbishments, especially in listed buildings. One commented:

> "*Building regulations evolve, and these must be integrated into refurbishment projects. Listed buildings or conservation areas require extra approvals… arboriculturists, conservation architects*."

Since new construction work must comply with current regulations, aligning them with older buildings can introduce unforeseen costs and delays. Additional surveys may be needed to assess historical construction methods, further complicating project timelines. All participants agreed that existing building conditions are critical to risk management and refurbishment complexities. The most significant challenges cited were lack of detailed surveys, incomplete asbestos records, and difficulties implementing modern regulations in older buildings.

Methods/Processes used to deal with complexities

This theme examines methodologies and processes used to navigate refurbishment challenges. Participants agreed that refurbishment projects are generally approached like new builds, despite the additional complexities. One participant noted:

> "*Refurbishment isn't treated much differently from a new build, except it requires more information, which isn't always available*." Another added: "*There are no distinct processes—it's what you'd expect in typical project management.*"

Despite no standardised approach, risk assessments were highlighted as a key differentiator. One participant stated:

> "*The main difference is risk assessment considering asbestos, confined spaces, and other site-specific factors. Asbestos detection, for instance, can cause delays and cost implications.*"

This highlights that refurbishment risks differ from new builds, requiring additional risk assessments and contingency planning. Most participants identified stakeholder coordination as a major factor in managing refurbishment projects. One noted:

> "*More coordination is needed between disciplines, but this isn't structured well.*" Another added "*Managing multiple governing bodies is complex—each has its own methodology.*"

This response underscores the importance of multi-stakeholder collaboration, particularly during planning and design. Some participants noted that planning approvals require extensive surveys, with one stating:

> "*Planning authorities have strict methodologies applying, complying, and obtaining approval requires existing site surveys and contamination reports*." Another emphasised "*Information must be gathered from different sources and consolidated effectively*."

The responses highlight the challenges of integrating methodologies across multiple disciplines and aligning them with local policies. Most participants highlighted that time and cost as the primary considerations in managing refurbishment projects. One participant noted:

> "*Most issues can be mitigated, but this often comes at a cost—appeasing the landlord or altering the design*." Another commented "*Hidden problems aren't discovered until work starts this makes costing and design difficult*."

Delivering on time and within budget was emphasised as a core measure of success. A participant stated:

> "*The key factors are delivering the job on time and within budget. Refurbishment projects are full of risks cost contingencies must be built into budgets.*"

The responses indicate that incomplete design information during initial stages often leads to design changes, rework, cost overruns, and delays. Ensuring compatibility between as-built information and new designs is crucial for minimising disruptions. Participants also noted that a lack of coordination between stakeholders often resulted in incorrect or irrelevant information being shared, highlighting the need for clearer processes.

Complexities faced during Completion

This theme aims to highlight response in relation to issues during and following completion of a refurbishment project. The focus of this theme was to identify common issues that can occur and how these are mitigated.

Most participants identified energy efficiency as a key factor when assessing the functionality of a building, post-completion. One participant stated:

> "*Replacing old equipment with more energy efficient equipment to bring bills down… clients think it costs more but in terms of efficiency it's a much better system*."

This response demonstrate that the up-front costs associated with upgrading and replacing existing systems can be expensive however the costs facing the client can be reduced over time. Whilst the initial costs may appear high, over the lifecycle of the building the client would see a reduction in cost and emissions. Another participant stated:

> *"We have built school where we have had to demonstrate the energy efficient of the building post-completion."*

This viewpoint indicated that in some cases, particularly in public-sector refurbishment projects it can be compulsory to demonstrate the energy performance of the building following completion. Additionally, participants highlighted the 'unknowns' within the existing building such as hidden or concealed services within the existing building fabric or finishes. One participant stated:

> *"You might think you know where everything runs… suddenly you take walls down and find equipment you didn't know existed that can affect the whole design process and lead to changes."*

Additionally, another participant highlighted the importance of obtaining the data and information pertaining to the existing building and carrying out detailed surveys:

> *"There is often a multitude of issues hidden beneath the finishes, so you have to mitigate by doing a good internal and external survey".* Another participant added *"as-installed information and where that information is located is not always available."*

Most respondents agreed that most problems that can occur during completion occur due to the lack of detailed surveys during the feasibility / design stages. One participant stated:

> *"Often plans are not updated accordingly… for example branches of drainage that may not picked up in initial surveys can lead to costly design stages"* Another participant added *"there's typically not enough inspection on site for MEP services."*

In terms of issues post-completion, one participant reported that problems can arise when making modifications to the existing MEP systems, stating:

> *"Internally it may be corroded but you can't always tell visually so if you haven't done destructive testing to determine the state then you can start to have leaks following completion and end up having to replace large sections that weren't in the original scope."* With another participant added *"Detailed investigation surveys and testing are required to base the design on."*

From this theme, it can be stated that participants were in agreeance that the as-built information relating to the existing building is a critical element of a refurbishment project. However, it was noted that this information is not always readily available and the lack of detailed surveys during the design stage can have a detrimental impact to the installation and commissioning of systems, particularly when aligning old systems with new. Failure to conduct surveys and testing during the early RIBA stages can results in increased project risk including delays, cost implications or complete design re-work to accommodate the existing systems/services. Using the components highlighted in table 2, and synthesising the findings with relevant building parts highlighted in table 1, the research suggests a hybrid framework that support richer and more holistic consideration of building performance for refurbishment projects (figure 2).

<Insert table 2 and figure 2 about here>

Validation of the framework

In order to assess the practicality of the proposed framework (figure 2) in achieving better accountancy toward building performance in this study, a validation session was conducted using focus group with six participants from a construction company who continually manage many refurbishment projects. The findings were analysed to identify patterns or themes using thematic analysis and used to develop a framework which was then fed back to participants to provide feedback. Focus group session was conducted with the same participants to validate the proposed framework and more importantly identify how it can support better recognition of performance elements for refurbishment projects. Table 3 contains quotations extracted from the feedback received.

<Insert Table 3 about here>

DISCUSSION

Uncertainty in existing buildings significantly impacts refurbishment project delivery and performance. Most respondents identified unknown elements such as structural and insulation conditions as major challenges. Data on components like window glazing, HVAC, and power distribution systems were often described as "limited" or undocumented, leading to design inaccuracies that affect thermal comfort, indoor air quality, and operational costs. Ranasinghe (2021) highlights that refurbishment projects are inherently high-risk and complex, with cost, time, and safety performance indicators often impacted by uncertainties in structural and mechanical installations.

Literature largely focuses on energy performance and sustainability, particularly thermal efficiency via insulation and HVAC modifications (Nydahl, 2019; Barbiero & Grillenzoni, 2019). However, technical impacts on broader project performance indicators—such as maintenance needs and occupant comfort related to electrical and plumbing installations—are underexplored (Okakpu et al., 2020). Project performance is typically assessed using the project management triangle: time, cost, and quality. Yet, uncertain building conditions shift these indicators, affecting lighting quality and water efficiency (Ali & Au-Yong, 2021). Smith et al. (2014) distinguishes between risk, where probabilities are known, and uncertainty, as seen in pre-existing piping and power distribution, which have unpredictable effects on occupant comfort and maintenance.

Refurbishment projects are inherently more conflict-prone than new builds (Noori et al., 2016). Despite this, methodologies often mirror those of new builds, failing to address unique issues in thermal performance, HVAC reliability, and lighting quality. Interviews revealed a common approach of merely "getting it over the line" rather than deploying structured methodologies for refurbishment-specific challenges like insulation weaknesses or aging plumbing (Lund et al., 2016; Kemmer, 2018). Surveys and inspections tend to be reactive rather than preventative, missing opportunities to address comfort and operational efficiency issues, such as window integrity or HVAC adequacy.

A more integrated approach is required, aligning stakeholder technical insights with project requirements to assess factors influencing building performance. This would enable measures tailored to building limitations, such as improving water efficiency in outdated plumbing or using digital scanning for accurate cladding assessments, ultimately enhancing project outcomes (Bocaneala et al., 2024; Mayouf, 2016).

Future of Building Performance for Refurb Projects

Most studies on building performance focus on new builds (Assaad, El-Adaway & Abotaleb, 2020), with no industry-specific model for refurbishment project performance management. Research largely examines sustainability improvements, particularly in energy and thermal performance. However, this study highlights the significant influence of technical factors such as structural integrity, mechanical installations, and water efficiency on refurbishment outcomes, underscoring the need for a dedicated performance model.

This research proposes a hybrid framework to improve refurbishment project delivery by structuring technical data collection. It emphasises early-stage assessment of unknown conditions, supporting risk management and informed decision-making during design. Key

technical factors such as HVAC efficiency, structural load-bearing capacity, and the suitability of openings are integrated to enhance project performance. Given the variability in refurbishment projects, the framework ensures a consistent yet adaptable approach.

The framework's first stage identifies key stakeholders responsible for gathering critical information on the existing structure, including structural components, services, asbestos, and building constraints. Participants highlighted challenges in accessing accurate technical data, particularly HVAC and electrical systems. Unlike new builds, which rely on standardised assumptions, refurbishment demands precise data. The framework integrates this into risk management, ensuring that risks and opportunities align with structural and operational constraints. This improves feasibility assessments, supporting design decisions based on existing conditions.

Participants noted that refurbishment performance indicators often derive from new-build methodologies, leading to oversights in refurbishment-specific factors like thermal insulation and plumbing efficiency. The framework develops performance indicators based on identified risks, aligning with client requirements while accounting for technical constraints. Existing research (Ilter & Ergen, 2015; Tasselli & Maietti, 2022; Al Bunni & Shayesteh, 2019) explores BIM and digital twins, but their application to lifecycle performance in refurbishment remains limited. This framework adopts an integrated approach, allowing stakeholders to standardise and share technical data throughout the project lifecycle.

Technologies such as BIM and 3D laser scanning improve digital information capture, embedding data within a central model. However, interoperability and reliability concerns persist (Bataw, 2016). Despite these challenges, all participants agreed that integrating advanced technologies would enhance project performance, facilitating real-time adjustments based on accurate technical data. The validation exercise highlighted industry fragmentation, reinforcing the need for a structured, technically informed framework for optimised project delivery and performance.

CONCLUSION

This paper proposed a mechanism to enhance building performance accountancy for refurbishment projects. Despite their inherent complexities, refurbishment projects remain under-researched, with unsuitable management approaches failing to address uncertainties in existing buildings. While refurbishment is often associated with time, cost, and quality issues, the literature primarily focuses on energy performance and sustainability, highlighting a disconnect between research and industry practice. Interviews with industry professionals revealed a lack of structured approaches, with managing existing data and information identified as a key challenge. Based on this analysis, a proposed framework was developed to improve project delivery and performance. Focus group validation indicated its practical applicability in industry. Future research will explore data-driven validation across different refurbishment contexts, including residential and commercial projects. Empirical case studies will assess its effectiveness, refining the framework to better address performance complexities in real-world settings.

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Figure 1: Bibliometric analysis highlighting where research focus is often on with relation to refurbishment and building performance.

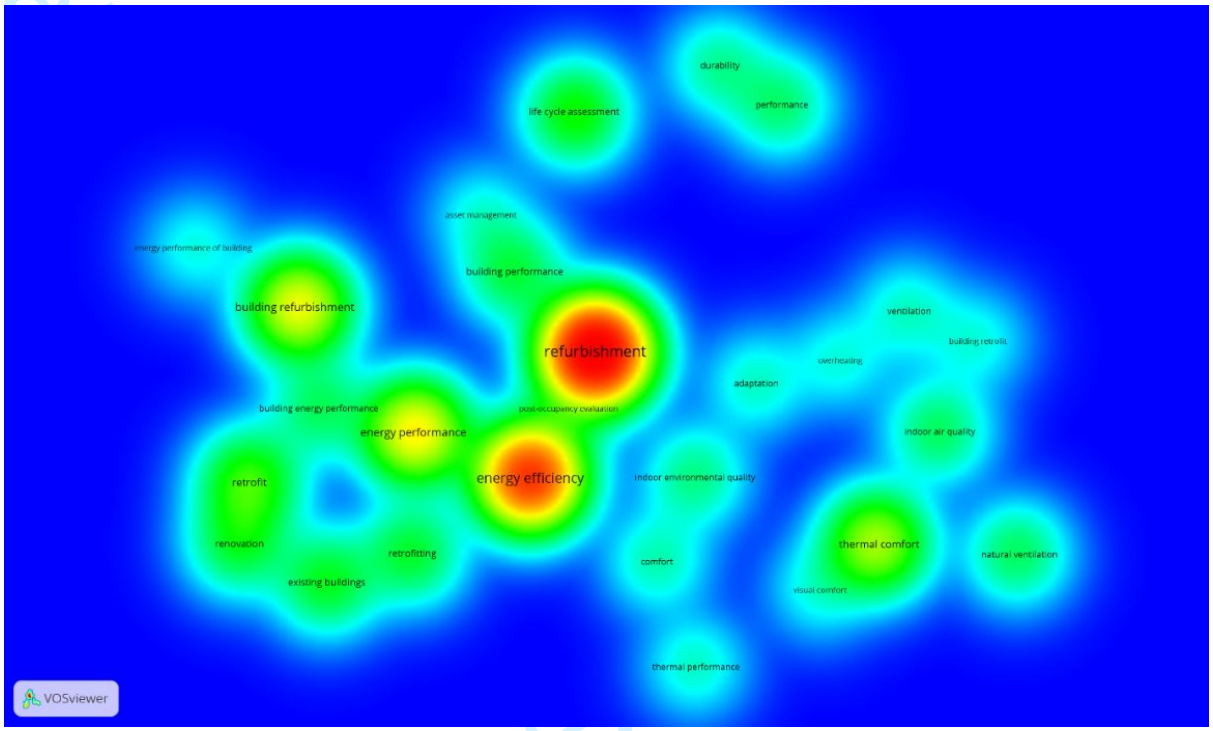

Figure 2: The proposed hybrid mechanism to improve performance accountancy for refurbishment projects

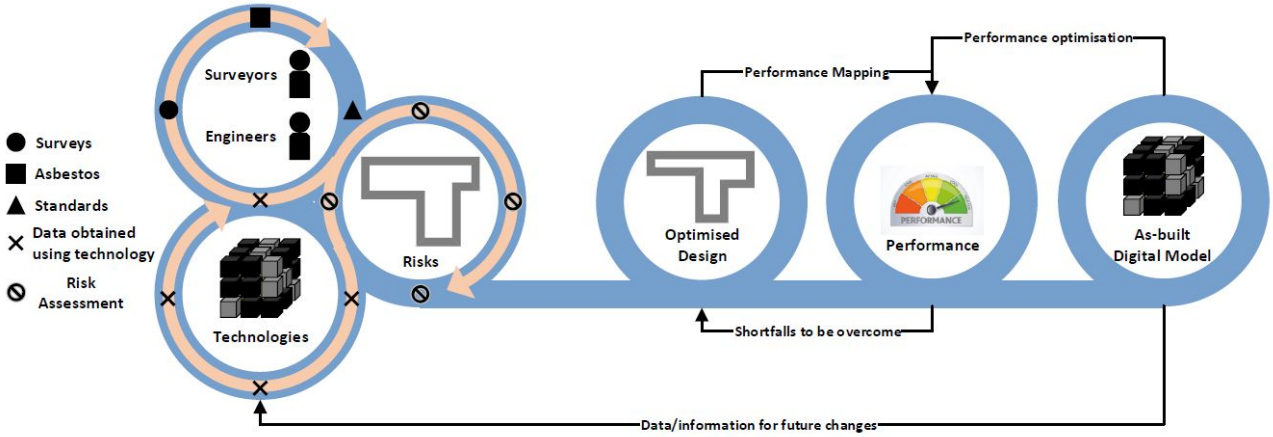

Table 1: Building Parts, associated components and their impact on building performance in the context of refurbishment projects

Building Part	Components	Impact on building performance	Study
Building Shell	Structural, Insulation, Reinforcements and cladding	Thermal comfort Operational costs Life span	Ali and Au-Yong (2021)
Openings (Doors and windows)	Window Glazing Door Replacement/alternatives	Indoor comfort Noise levels Property Value	Ranasinghe et al. (2021) Okakpu et al. (2020)
Mechanical Installations	Heating, Ventilation, Air Conditioning (HVAC)	Indoor Air Quality Maintenance needs Occupant comfort	Ranasinghe et al. (2021) McKim et al. (2000)
Electrical Installations	Lighting Systems Power Distribution	Lighting Quality Maintenance needs Occupant comfort	Bortolini and Forcada (2018)
Plumbing Installations	Piping, Fixtures, Water Heating and Cooling Systems	Water Efficiency Utility Costs Maintenance needs Occupants comfort	Ali and Au-Yong (2021) Okakpu et al. (2020)

Table 21: Proposed hybrid framework components

Component	Explanation	Evidence	Relevant Building Part
Stakeholder	~~Stakeholder engagement during the early phases was identified as a challenge on refurbishment projects, particularly when exchanging and collating information in relation to the existing building. Following feedback from the participants, this framework identifies the key personnel that should be considered during the early stages and stipulates who are primarily responsible for gathering data and information.~~ This stage focuses on stakeholders involved in the initial phase of a refurbishment project, which would typically include surveyors and engineers. In this stage,	*Interviews*	Building Shell Openings Mechanical Installations Electrical Installation Plumbing Installations

	the focus would typically be ~~is integrated with the risk stage as the information obtained, such as~~ surveys, asbestos registers, drainage, existing services etc. ~~will be incorporated into the risk management strategy with the use of digital technology.~~		
Risks	This stage focuses on typical risks that often impact the ~~This stage is designed to be integrated with the initial stage to develop a risk management strategy based on the outcome of the data and information gathered. Feedback obtained during the interviews highlighted the complex risk factors that can have a major impact on overall project performance. To better manage risk and opportunities, this framework implements the risk management strategy during the initial phase so risks can be developed in accordance with project characteristics to ensure that the design is developed in line with the level of risk. Feedback from respondents suggested that risk is often assessed in parallel with~~ design development, and this is associated with unknown risks that often stem from existing mechanical, electrical and plumbing systems. ~~which doesn't provide a clear indication of programme or project cost.~~	*Interviews*	Mechanical Installations Electrical Installation Plumbing Installations

Technologies	This stage focuses on the importance of having centralised ~~framework incorporates the application of technologies to support data and information management for refurbishment projects. Feedback suggested that often the way in which information is shared and stored can present interoperability issues particularly when working with multiple stakeholders. This can present further issues when existing information such as O&M manuals is inaccurate or missing. This approach would allow~~ data and information platform (e.g. BIM) ~~to be standardised within a common data environment for the lifecycle of the project. Furthermore, it would allow the information to be collated into an as-built model to be used for any future works. Many participants reported that the use of digital technologies such as laser scanning would provide a non-intrusive solution to capture accurate survey data.~~to capture additional issues that have not been picked by surveys or historical data, and also to allow progressive accountancy towards whole life cycle.	*Interviews*	Building Shell Openings Mechanical Installations Electrical Installation Plumbing Installations

Optimised Design	The stage focuses on the geometric side of the design, and focuses on the integrity of different systems within the refurbishment project. This stage allows setting priorities for the project team, and primarily aims to ensure that project requirements are fulfilled.~~The integration of risk management during the initial stages aims to facilitate and streamline the design process. All of the participants agreed that availability of information was critical in order for the design to be developed in line with the parameters of the existing building. Often this information isn't readily available which can have a direct impact on the performance of refurbishment design. Feedback indicated that any decisions made during the design process can have a major influence on overall project performance. The framework aims to alleviate the level of uncertainty by conducting surveys during the early phases to understand the constraints / limitations of the existing building for its intended use and ultimately, determine the scope.~~	*Interviews* ~~+ *Analysis*~~	Building Shell Openings Mechanical Installations Electrical Installation Plumbing Installations

Performance	This stage focuses on indicating performance indicators within the merits of refurbishment project scope. Most participants stated that the methods and processes used to manage performance did not differ from new-build projects. ~~Due to level of uncertainty associated with refurbishment projects, this approach is not suitable and can result in poor project performance as the performance indicators do not take into account the constraints / limitations of the existing building.~~ The framework is designed to ensure the performance measures are ~~developed in accordance with risk management strategy whilst taking into account what is achievable within the parameters of the existing structure.~~appropriately defined and identified when design is optimised.	*Interviews* ~~+ Analysis~~	Mechanical Installations Electrical Installation Plumbing Installations
As-built Digital Model	The use of a Building Information ~~Modelling would~~Modelling would allow data and information to be stored in a centralised database linked to a 3D model which would improve collaboration between stakeholders. ~~Feedback suggested that the as-built information can come in many forms such as 2D drawings, specifications, O&M manuals etc. however often this information is inaccurate or missing. Participant's feedback stated that often the building users / facilities manager do not understand the importance of~~	*Analysis*	Building Shell Openings Mechanical Installations Electrical Installation Plumbing Installations

	~~updating the as-built information as modifications / changes occur to the building.~~ This framework proposes the use of an as-built digital model to improve interdisciplinary collaboration between stakeholders by sharing and storing data and information in a CDE. In terms of building performance, this would allow the buildings operational performance to be measured.~~.~~ It could also be used for any future works.		

Table 3~~2~~: Extracted quotations from the interviews conducted with participants

Stage	*Value*	*Potential Concerns*
Stage 1 – (Identifying key stakeholders and obtaining information)	*"A model like ~~this highlights~~this highlight why the cost needs to be there for initial investigations and surveys and also highlight the time spent upfront."* *"With such a ~~framework,~~ ~~you~~framework, you will prompt many important aspects such as cost at the beginning of the process, but you would get the value back at the other end."*	*"Accuracy of requirements can impact different stages of the refurbishment project, and can prompt more risks if not captured early on"*

Stage 2 – (Risk Management)	*"I really like the idea that all the front end work should be done early on. It takes time to look at things properly"* *"I think the risk element being well before the design is massive because jobs can be designed to RIBA Stage 4 and then costed and it's full of risk."* *"That risk stage before the optimised design is what is missing from our process – most processes start with the client requirements fed into design, then drawings are produced and costed."*	*"Accurate layout of MEP services can hugely impact design decisions"*
Stage 3 – (Use of Technology)	*"The technology aspect is really good, you could have a model that you could refer to that, centrally would have all the information… that would be useful at that stage."* *"Clash detection is huge on refurbs, technology is important because they can see the building as a whole and not just their part of the job."* ~~*I really like this idea – particularly how the technology aspect can provide a one-stop shop where information is readily available."*~~	*"My concern with technology is it requires the people to use it properly, often people just want to push a project through."*
Stage 4 –	*"I think it's a really good idea, especially for design optimisation*	*"With any model it has to have time to be benchmarked, particularly during*

(Optimised Design)	*there are many difficulties faced to assure that the design response to the end user needs."* *"This framework would definitely help minimise variations – often variations can start racking up, particularly on refurb jobs because the project was treated as a new build in that it wasn't giving information that was specific to that building during design."* *"Sometimes the design can be finalised and approved by the client before the risks have been assessed and managed – which can affect the overall project performance later down the line."* ~~*"At first glance I thought design should be at the early stages, but this is much better, it should definitely be further down the line to capture all the risk."*~~	*design stages which gives an indication depending on the size of the project… you could work estimated times into the model."*
Stage 5 – (Performance)	*"As an industry having a process like this can be really important which can contribute to increased performance and delivery, particularly when considering the complexities of a refurbishment project"* *"Sometimes the process isn't clear, when you have an idea of your starting point and the next steps that makes what you are proposing is*	*"This significantly can vary from a project to another, so there is always a need to go back amend designs according to performance measures"*

	important and very useful and in turn will contribute towards project performance during the later stages." *~~"Having a framework like this is really important so that people can actually see what they are trying to achieve and can help improve performance and overall project success."~~*	
Stage 6 – (As-built Digital Model)	*"Often people can hand you some poor as-built drawings – how do you know what's going on in your building if you come to do any further works, so I like the idea of incorporating that into the framework."* *"The as-built model at the end would be massively beneficial if we could go into a central data system to view the properties of the existing building."* *"I think we can benefit from many of the heritage projects being refurbished across Europe as they tend to focus a lot on mapping data captured and how it can support optimising performance in the long term."*	*"There would be a lot of work in taking the information and capturing it in a relevant data form, but it would be really helpful."* *"It will only be as good as the people who are inputting the data, to utilise the data it would labour intensive initially."*