Guidelines for Lean Premise Design (LPD) Scheme Implementation in High-rise Residential Buildings

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1.0 Introduction

The implementation guidelines for the lean premise design (LPD) scheme aim to improve sustainability adoption in Hong Kong by eliminating faulty design and minimizing abortive work in the development of high-rise residential (HRR) buildings. The LPD scheme will enhance the reduction of construction and demolition waste. The LPD guidelines will benefit project stakeholders and end-users of HRR buildings. Stakeholders in HRR buildings include individual professionals or groups who have a vested interest in the outcome of a project such as investors, local authorities, building developers, designers, property managers, and individuals or groups who will ultimately use or occupy the high-rise residential building, such as homeowners, renters, or tenants. This section gives a brief explanation of the keywords recognized and discussed in this guideline, such as “LPD”, “latent defects” and “end-user requirements”.

1.1 The lean premise design scheme

The LPD approach is a design approach that emphasizes a simplified and streamlined method to design, with a focus on reducing waste, time, and cost in the development process. This approach seeks to eliminate waste and focus on delivering value to the customer by engaging stakeholders in the design process, prioritizing customer needs, and basing design decisions on data-driven insights. When it comes to HRR building design, the LPD approach can be beneficial in ensuring that the design meets the needs of end-users while minimizing waste and cost. LPD means that only essential outfitting, such as water and gas supply, waste disposal, sanitary fittings, windows, lighting outlets, and the like, will be supplied in new residential buildings. On the other hand, internal finishing, built-in facilities such as kitchen and bathroom cabinets, cooking ovens, and air conditioners will not be installed (Lam, et al., 2022).

Additionally, the LPD approach can help to identify key requirements for end-users such as amenities, layout, accessibility, and safety. These requirements should be identified early in the design process and used to guide the decision-making process throughout the project. By doing this, designers can ensure that the final design meets the needs of the end-users, resulting in a highly functional and attractive living space. Overall, the LPD approach can be highly effective in HRR building design by streamlining the design process, engaging stakeholders, prioritizing customer requirements, and basing design decisions on data-driven insights. It is worth noting that LPD designers and stakeholders must put adequate safeguards in place to ensure that the LPD scheme does not appear less appealing (design-wise) to buyers.

1.2 End-user requirements in HRR buildings

End-user requirements in HRR buildings refer to the needs and expectations of the individuals or groups who will ultimately use or occupy the building, such as homeowners, renters, or tenants. These requirements may include various factors related to the building's design, functionality, and safety. Some of the key end-user requirements in HRR buildings may include features such as sufficient natural light, accessible and efficient elevators, adequate heating, ventilation, and air conditioning (HVAC) systems, secure entry and exit points, sufficient storage space, and accessibility features for individuals with disabilities. Other important factors may include privacy, noise reduction, and comfortable and functional living spaces. Meeting end-user requirements is essential for ensuring the safety, comfort, and long-term satisfaction of residents in HRR

buildings. Therefore, it is important for designers, builders, and property managers to carefully consider and prioritize these requirements throughout the design and construction process.

1.3 Common latent defects in HRR buildings

Latent defects in the development of HRR buildings refer to the defects or conditions of construction that exist but are not immediately apparent or visible. These hidden defects may include issues with the building's foundation, structural design, electrical wiring, plumbing, or other components that can cause problems for occupants or result in building failure over time. Latent defects may not be apparent during the construction or inspection phases but can become apparent later during the building's occupancy. These defects may result from poor workmanship, use of substandard materials, or other factors related to the building's design and construction.

2.0 Critical factors of LPD scheme adoption

2.1 Barriers to LPD scheme adoption

The identified barriers are knowledge and skill; support, communication, and feedback; perceived benefit; finance and implementation time; culture; design practices; user's requirements and procurement; and environment and regulation. Stakeholders can collaborate to identify and mitigate these barriers to facilitate a successful implementation of the LPD scheme. To identify each barrier of LPD scheme in a building project, a comprehensive review and assessment of the project design and construction processes should be conducted. Likewise, the barriers can be improved through active efforts to identify and address them, such as developing alternative solutions, engaging stakeholders in problem-solving, or providing LPD-based training or resources to overcome the identified challenges or barriers.

(i) **Knowledge and skill**: This barrier refer to a lack of knowledge and expertise among stakeholders in the Lean Premise Design (LPD) approach. In practical terms, it means that those involved in the design process may not understand what the LPD approach entails or how to employ its principles.

(ii) **Support, communication, and feedback**: This barrier denotes a lack of support from management, as well as poor communication and feedback throughout the design process. This barrier can manifest as a lack of resources and guidance, insufficient communication channels and feedback loops, and a lack of support for experimentation and risk-taking.

(iii) **Wrong perception of LPD scheme**: This barrier relates to a lack of buy-in from stakeholders who may not see the value of adopting the LPD approach. In other words, it means that stakeholders, such as the architectural and structural designers may view LPD as a time-consuming and burdensome process, rather than one that adds value.

(iv) **Finance and implementation time**: This barrier refers to the financial and temporal costs associated with implementing the LPD approach. This can mean that stakeholders are unwilling or unable to allocate the necessary funds, resources, and time to adopt LPD completely.

(v) **Culture**: This barrier refers to an organizational culture that may not be conducive to the principles of LPD, such as open communication, experimentation, and risk-taking. It includes stakeholders' resistant to change and preferences for traditional design methods.

(vi) **Design practices**: This barrier refers to the established design practices and processes in an organization or industry that may be difficult to change or challenge. This can also mean the reluctance to embrace new or unfamiliar design methods by designers.

(vii) **User's requirement and procurement**: This barrier relates to the procurement process and the requirements of users, which may not align with the principles of LPD. In practice, it means that the user's requirements may be too specific or too numerous, making it difficult to implement LPD successfully.

(viii) **Environment and regulation:** This barrier refer to environmental and regulatory factors that may limit the flexibility of stakeholders in the design process. In practical terms, it means that stakeholders may be constrained by factors such as environmental regulations, safety standards or zoning laws, which can make it challenging to adopt the LPD approach.

2.2 Drivers of LPD scheme adoption

Understanding these drivers and their practical implications will help stakeholders work towards successfully adopting the LPD scheme in Hong Kong's HRR buildings. The identified drivers are design and management; sustainable management; off-site construction method; training and collaboration; government's involvement and support; and cost efficiency. The drivers can be reinforced by aligning them with project goals and objectives, promoting stakeholder communication and collaboration, and providing incentives or rewards for meeting quality improvement targets. However, to identify each driver in a project or organization, it is useful to conduct a comprehensive analysis of the project design and construction processes. LPD scheme aims to promote sustainable, efficient, and user-oriented building design and construction practices.

(i) **Design and management**: This driver represent a shift towards an integrated and collaborative approach to design that involves all stakeholders, including architects, engineers, and contractors. Practically, this means that the design process will be more streamlined and efficient, with a focus on reducing waste and eliminating redundancies.

(ii) **Sustainable management**: This driver highlights the importance of sustainability in the design and construction process, with a focus on reducing energy consumption and minimizing waste. This means that sustainable materials and practices will be prioritized, and energy-efficient systems will be incorporated into the design.

(iii) **Off-site construction method**: This driver highlights the use of off-site construction methods, such as pre-fabrication and modular construction, to reduce waste and improve efficiency. Essentially, this means that more components will be produced in a controlled factory environment and assembled on-site, reducing the amount of time and resources needed for construction.

(iv) **Training and collaboration**: This driver underline the importance of training and collaboration among stakeholders to ensure that everyone is equipped with the necessary knowledge and skills to implement LPD successfully. It entails providing training and resources to all parties involved in the design and construction process and fostering a culture of collaboration and open communication.

(v) **Government's involvement and support**: This driver underscores the importance of government involvement and support in the implementation of LPD. It focuses on government's provision of funding and resources to support the adoption of LPD, as well as implementing policies and regulations that incentivize its use.

(vi) **Cost efficiency**: This driver stresses the importance of cost efficiency in the design and construction process, with a focus on reducing waste and minimizing unnecessary expenses. Simply, this means that the design and construction process will be optimized to reduce costs while maintaining quality standards and meeting customer needs.

2.3 Benefits of adopting the LPD scheme

The identified benefits are built environment sustainability; efficiency in project management; user-oriented design; better design and marketing consideration; safety and process efficiency; and ease of conformance to user requirements. By recognizing these benefits for Hong Kong's construction industry and the built environment, stakeholders may work toward adopting the LPD scheme. To identify each benefit in a project or organization, it is necessary to conduct a detailed analysis of how the LPD scheme can be integrated into the project design and construction processes. Meanwhile, the LPD benefits can be maximized by regularly

evaluating and measuring the impact of quality improvement efforts, promoting transparency and accountability for outcomes, and communicating successes to all participating stakeholders.

(i) **Built environment sustainability**: This benefit highlights the importance of sustainability in the built environment and the reduction of negative environmental impacts. In practical terms, this means that the LPD scheme will prioritize sustainable materials and practices, energy efficiency, and waste reduction during the design and construction process.

(ii) **Efficiency in project management**: This benefit stresses the importance of streamlining and optimizing the project management process to reduce waste, save time, and improve productivity. In practical terms, this means that the LPD scheme will prioritize efficient communication and collaboration between stakeholders, as well as the use of digital tools and technologies to facilitate workflow and reduce errors.

(iii) **User-oriented design**: This benefit underscores the importance of designing buildings that meet the needs and preferences of the users, as well as their safety and well-being. This means that the LPD scheme will prioritize user research and feedback, as well as the use of design thinking methodologies to ensure that the design is user-centered and responsive.

(iv) **Better design and marketing consideration**: This benefit put emphasis on the importance of design and marketing consideration in the success of a project. This means that the LPD scheme will prioritize aesthetics, functionality, and marketability in the design process, as well as the use of marketing strategies and tools to promote the project and generate interest.

(v) **Safety and process efficiency**: This benefit stresses the importance of safety in the construction process and the optimization of construction processes to reduce risks and improve efficiency. In other words, this means that the LPD scheme will prioritize safety training and protocols, as well as the use of process optimization tools and technologies to reduce errors and improve productivity.

(vi) **Ease of conformance to user requirements**: This benefit highlights the importance of meeting user requirements and preferences in the design and construction process. The LPD scheme seeks to prioritize user research, feedback, and collaboration throughout the project, as well as the use of digital tools and technologies to facilitate communication and workflow.

2.4 Facilitating measures for the LPD scheme adoption

Adoption of the LPD scheme in Hong Kong can be accelerated and streamlined by implementing the facilitating measures, resulting in more sustainable and user-oriented building designs, improved project management efficiency, and better communication and collaboration between stakeholders throughout the project lifecycle. Like in other factors, to identify each facilitating measure in a project, there is need to understand the principles of the LPD scheme and how they can be applied in the design and construction processes. These facilitating measures can be enhanced by regularly reviewing and updating design and construction practices to reflect the latest industry standards and best practices, providing resources and training to help stakeholders use new technologies and methodologies, and evaluating the effectiveness of design and construction practices over time. Figure 1 depicts the response frequency of the identified facilitating measures of LPD based on a questionnaire survey with 65 experts in the Hong Kong's building construction industry. Furthermore, as recommended by the experts in this survey, LPD should be implemented at the planning and design stages of HRR buildings to facilitate effective sustainability implementation (Figure 2).

(i) **Policy mandate**: This facilitating measure accentuates the importance of having government policies and regulations in place that mandate the adoption of the LPD scheme in building design and construction. Practically, this means that the government should set regulations and targets for sustainable building design and would require that all new buildings and major renovations comply with the LPD scheme to reduce negative environmental impacts and improve sustainability.

(ii) **Communication and digital technologies**: This facilitating measure underlines the importance of utilizing modern tools and technologies to facilitate communication and collaboration between stakeholders in the design and construction process. This means that digital tools and technology will be utilized to improve communication among stakeholders such as architects, engineers, contractors, and owners, as well as to enable the sharing of data and information throughout the project lifecycle.

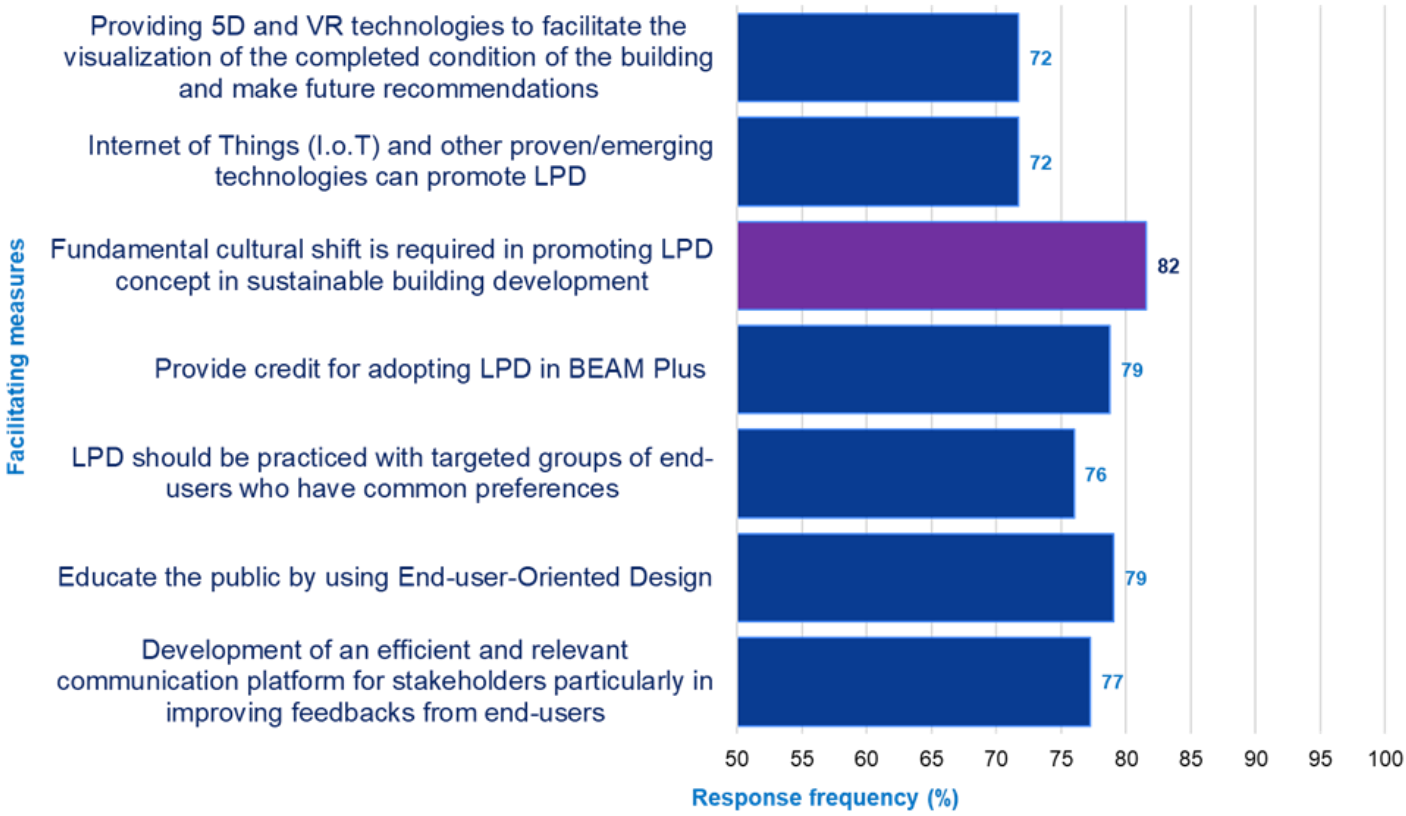

Figure 1: Facilitating measures of LPD.

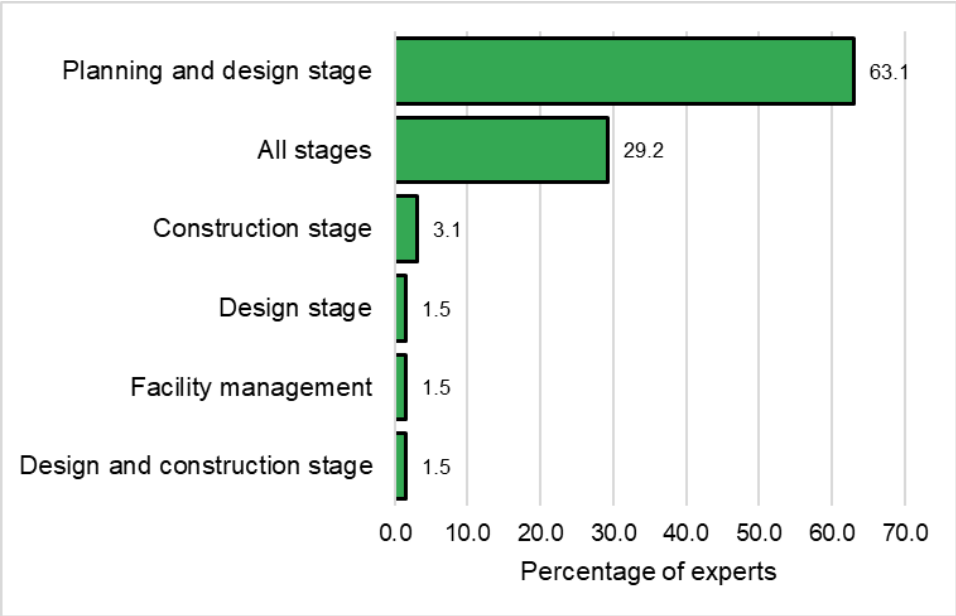

Figure 2: Experts' opinion on stage to implement sustainable practices in HRR development

2.5 Minimum and acceptable LPD critical factor requirements

There is no specific minimum criterion for acceptable drivers, barriers, advantages, and facilitating measures, as these might vary depending on the context and goals of each unique project. However, efforts should be made to address barriers and maximize benefits while promoting effective drivers and facilitating measures to ensure successful project outcomes. The success of these initiatives can be measured through regular feedback and evaluation processes. The effectiveness of these efforts can be evaluated using regular feedback and evaluation processes. Significantly, ensuring the success and sustainability of LPD schemes requires an ongoing commitment to quality improvement and best practices.

3.0 End-user requirements in Hong Kong's high-rise residential buildings

This section identifies the relevant user requirements in HRR buildings. According to the findings of this study, respondents with an annual income of more than 200,000 HKD ranked higher than the requirement that developers should provide a variety of internal finishings and fittings. This suggests that high-income earners are more likely than low-income earners to choose from a variety of interior design options. Furthermore, end-users with relatively low household income prefer connecting indoor space to the exterior, such as a balcony, over end-users with higher household income. The important users' requirements and expected built-in facilities in Hong Kong's HRR buildings are highlighted in Table 1.

Users' interests may contradict basic design and engineering considerations because some building end-users have limited knowledge of building design. Thus, while end-users' demand is useful for professional designers, it is not the ultimate design guide because most users lack knowledge about the long-term benefits of designs. However, it is important to identify and provide users' requirements as designers. However, as designers, it is critical to identify and meet the needs of users. Figures 3 and 4 depict the design requirements of typical HRR building end-users (87 respondents in questionnaire survey) and the key building built-in facilities, respectively.

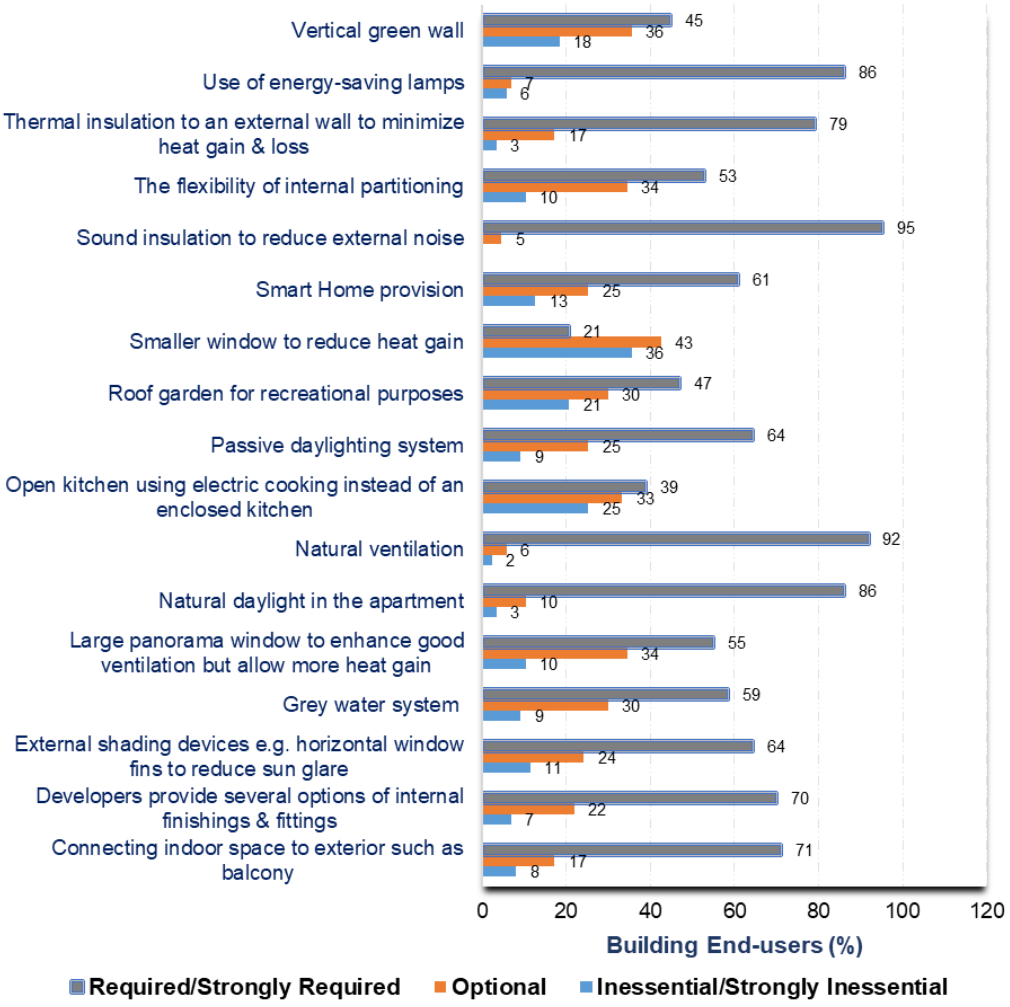

Figure 3: End-users' requirements in HRR buildings

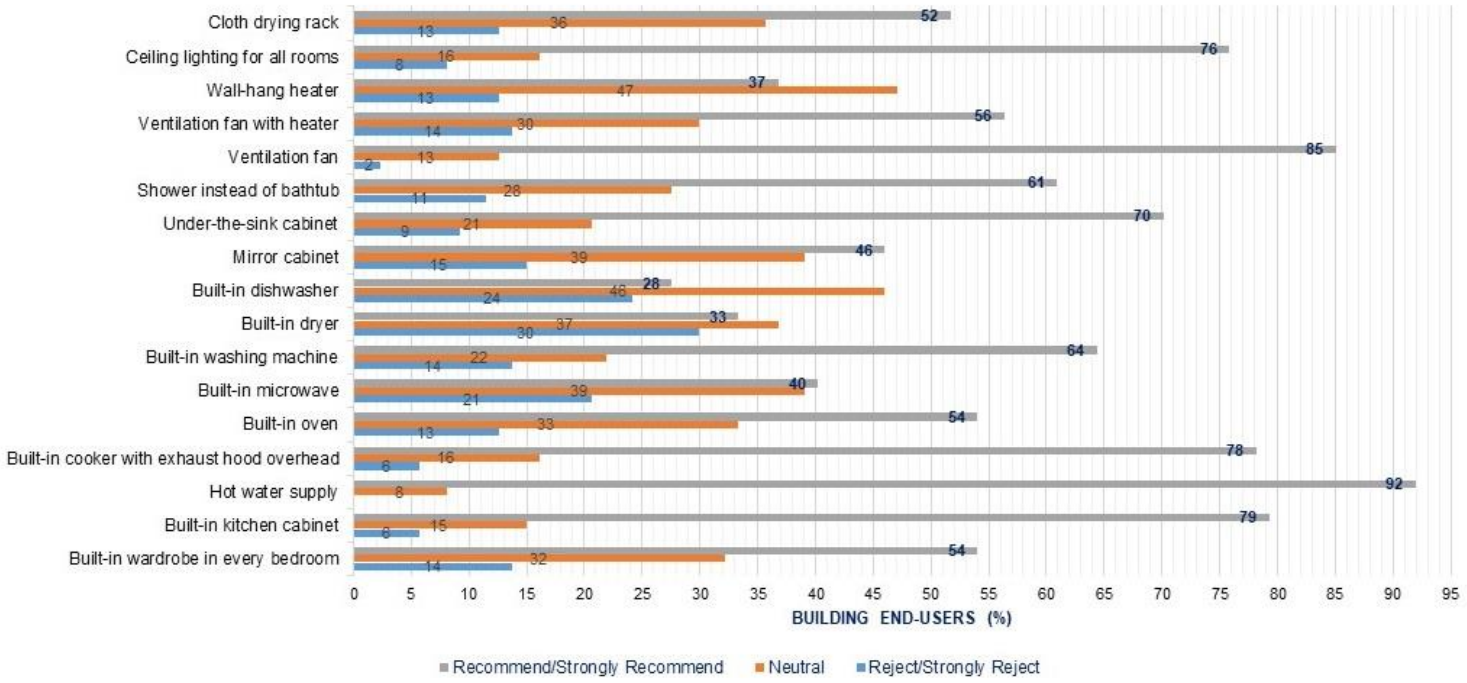

Figure 4: Users preferences on Built-in Facilities in HRR buildings

Table 1: Users' requirements and expected built-in facilities.

S/N	End-user requirement and built-in provision	Practical implementation
1	Sound insulation	Ensuring that walls, floors, and ceilings have adequate insulation to reduce external noise.
2	Natural ventilation	Designing windows and vents that allow fresh air to circulate throughout the building.
3	Use of energy-saving lamps	Installing energy-efficient lighting fixtures, such as LED bulbs or CFLs.
4	Natural daylight in the apartment	Designing windows and skylights that allow natural light to enter the apartment.
5	Thermal insulation to an external wall	Ensuring that the walls are well-insulated to minimize heat gain and loss.
6	Connecting indoor space to the exterior	Providing balconies or other indoor/outdoor connectivity options.
7	Developers provide several options for internal finishings and fittings	Providing a variety of finishings and fittings options to cater to the needs and preferences of different end-users.
8	Passive daylighting system	Incorporating passive design measures such as shading devices or reflective surfaces to optimize natural light.
9	External shading devices	Installing horizontal window fins or other shading devices to reduce sun glare.
10	Smart Home provision	Providing smart home technologies and features to optimize energy efficiency and enhance occupants' comfort and convenience.

S/N	End-user requirement and built-in provision	Practical implementation
11	Grey water system	Providing a system to recycle household water for non-potable use, such as flushing toilets or watering plants.
13	The flexibility of internal partitioning	Designing internal partitioning in a way that allows it to be adjusted or modified as needed
14	Inclusion of recycling facilities	Providing recycling facilities and programs to encourage sustainability and responsible waste management.
15	Hot water supply	Ensure that the hot water system is designed and installed to provide reliable and consistent hot water supply throughout the building.
16	Ventilation fan	Install high-quality ventilation fans in all rooms to ensure adequate air circulation and reduce indoor air pollution.
17	Built-in kitchen cabinet	Design and install kitchen cabinets that are spacious and provide ample storage space for utensils and appliances.
18	Built-in cooker with exhaust hood overhead	Install cookers with overhead exhaust hoods to improve indoor air quality by venting cooking fumes and odors outside.
19	Ceiling lighting for all rooms	Ensure that all rooms have sufficient ceiling lighting to make the indoor environment bright and comfortable.
20	Under-the-sink cabinet	Design and install under-sink cabinets to store cleaning supplies and maximize available storage space
21	Shower instead of bathtub	Consider installing showers instead of bathtubs to save water and space and improve accessibility
22	Ventilation fan with heater	Install ventilation fans with heaters in bathrooms to maintain a comfortable indoor temperature during cold weather.
23	Built-in oven	Install built-in ovens in the kitchen to save space and provide convenience for cooking.
24	Built-in wardrobe in every bedroom	Design and install built-in wardrobes in every bedroom to provide storage space for clothes and personal items.
25	Cloth drying rack	Consider installing cloth drying racks in the laundry area or on the balcony to provide a convenient and efficient way to dry clothes.
26	Fully furnished kitchen	Design and install fully furnished kitchens that include modern appliances and fixtures to provide convenience and improve the overall quality of life for the end-users.
27	Air-conditioner	Install efficient air-conditioning systems to ensure comfortable indoor temperatures during hot weather.
28	Bathroom cabinet	Install spacious bathroom cabinets to store personal items and reduce clutter in the bathroom.
29	Fully furnished washing room	Design and construct fully furnished washing rooms that include washing machines, ironing boards, and other

S/N	End-user requirement and built-in provision	Practical implementation
		necessary amenities to make laundry more convenient for end-users.
30	Cloth drying facility	Provide cloth drying facilities such as drying racks or designated areas that are protected from weather elements for efficient drying.

3.1 Practical implementation of the LPD scheme and end-user requirements

Lowering the cost of LPD apartments rather than raising them will inspire buyers to consider purchasing apartments built using the LPD approach. As shown in Figure 5, as the percentage increase in price increases, potential buyers become less inclined to pay over market price. Similarly, Figure 6 demonstrates that a larger discount on the purchase price will entice more purchasers to select the LPD scheme. In general, reduced stamp duty, together with other methods such as financial and market-based incentives (Chan et al., 2017) for LPD adopters, can help cut the overall cost of the property, making it more affordable for potential buyers (Berawi et al., 2020). Figure 7 shows that 86 percent of the respondents in the survey involving 87 HRR building occupants will be attracted to LPD if there is a stamp duty reduction on property for purchasing LPD based buildings.

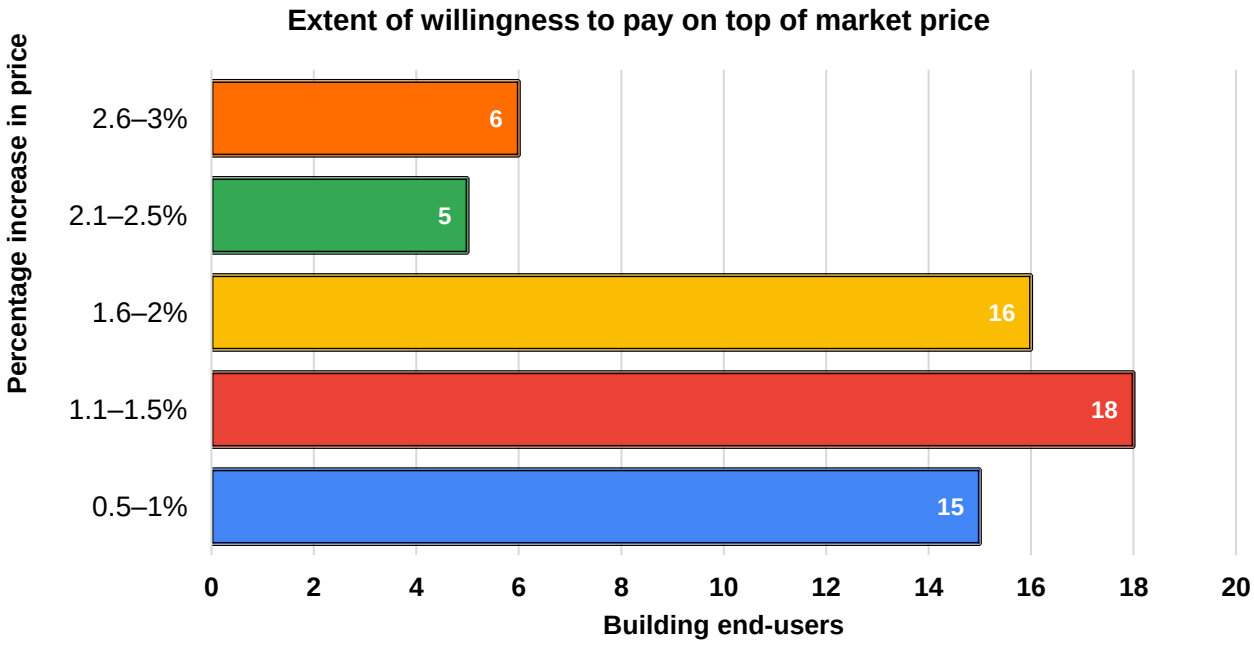

Figure 5: Payment on top market price

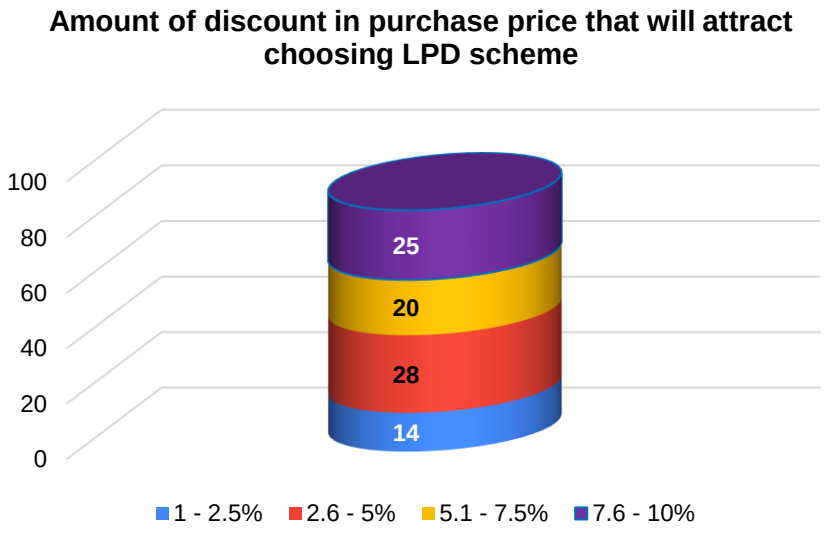

Figure 6: Discount in purchase price to attract buyers

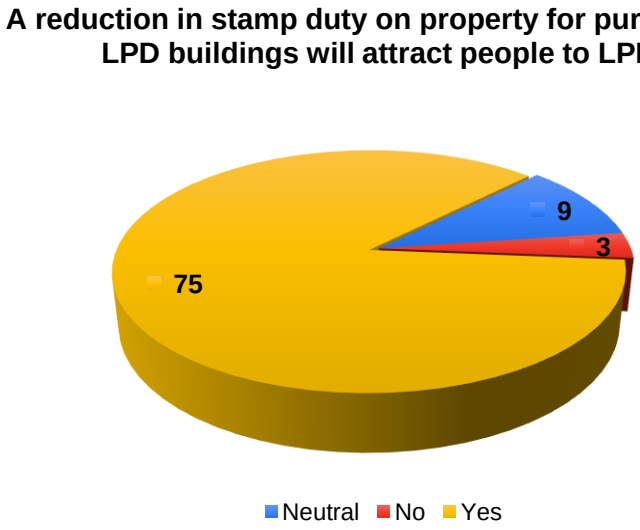

Figure 7: Reduction in stamp duty for purchasing LPD building

Furthermore, to ensure proper implementation of the requirements and built-in facilities, the various components must be included in the design specifications and correctly installed and maintained throughout the building's lifecycle. The implementation processes will be determined by the building's design, budget, and construction process, as well as the demands and preferences of the end users. In addition, regular feedback and evaluation throughout the building's life cycle can help guarantee that end-user needs are met and identify potential for further improvement.

3.2 Who is responsible for implementing end-user requirements in LPD?

In the LPD scheme, meeting end-user requirements for important built-in facilities involve a collaborative

effort involving all stakeholders, including the building's owner, architect, engineer, contractor, building service manager, interior designer, and end-user. The architect is responsible for ensuring that the building design and construction plans incorporate the end-users' requirements for vital built-in facilities, such as hot water supply, ventilation fans, under-sink cabinets, and built-in wardrobes. The architect should work closely with the end-users to identify their specific needs, prioritize them, and incorporate them into the design plan. Similarly, the engineer is responsible for ensuring that the building systems, such as the HVAC, electrical, and plumbing systems, are designed and installed to meet the end-users' needs for vital built-in facilities. The engineer should work with the architect to ensure that the building design and construction plans meet local codes and regulations and are energy-efficient and environmentally sustainable.

Furthermore, the contractor is responsible for ensuring that the building is constructed to meet the end-users' requirements for vital built-in facilities. The contractor should work with the architect and the engineer to ensure that the building is constructed according to the design plan and meets quality control standards. The building service manager is responsible for ensuring that the building is maintained to meet the end-users' ongoing needs for vital built-in facilities. The building service manager should work with the end-users to identify any maintenance issues and prioritize them for repair or replacement.

Most importantly, the end-user is responsible for communicating their needs and preferences for vital built-in facilities to the architect, engineer, contractor, building service manager, and interior designer. The end-user should be actively involved in the design and construction process, providing feedback and suggestions to ensure that the building meets their needs and expectations.

3.3 Approach to aligning end-users' needs and requirements

Effective communication and collaboration among end users, architects, engineers, contractors, building managers, and interior designers is one technique for aligning end users' requirements with their real needs. End-user wants and preferences should be discovered and included in design plans, with a focus on offering practical and efficient built-in fixtures and components that fulfil their requirements. The goal should be to minimize unnecessary or excessive provision of built-in fixtures and components, which can be accomplished with adequate planning and clear communication among all parties concerned. To ensure that the building design and construction fulfil sustainability, energy efficiency, and environmental goals, the LPD philosophy and goal should be considered throughout the process. Additionally, maintenance and facility management works should consider the needs of the end users to ensure that the building continues to function effectively and efficiently over its lifetime.

4.0 Latent defects in Hong Kong's high-rise residential buildings

Latent defects arise when the designs and requirements of the building designers do not align with those of the end-users. Faulty design generally causes more latent defects than workmanship generating many maintenance problems (Forcada et al., 2013). In a Delphi survey involving 10 experts in Hong Kong's construction industry, three latent defects were identified as critical defects that must be addressed in the LPD scheme for HRR building development. The important and critical latent defects are highlighted in Table 2 and are subsequently discussed.

Table 2: Important latent defects to be considered in the LPD scheme for HHR buildings

S/N	Latent defects	Significance
1	External pipes inconvenient for maintenance e.g., lack of maintenance platform	**Very important**
2	Poor curtain wall design leading to difficult access for maintenance	**Very important**
3	Inadequate working drawings and specification	**Very important**
4	Incomplete or incorrect working drawings and details	Important
5	Inadequate space, size, and location of ductwork	Important
6	Ignorance of materials performance	Important
7	Design and technology not user friendly to end-users and maintenance personnel	Important
8	Structural design is not flexible for future renovation (e.g., alteration in layout plan)	Important
9	Lack of parallel or cross ventilation in bedrooms	Important
10	Foul odour transmission due to inappropriate positioning of kitchen and toilets	Important
11	Insufficient number and misdistribution of electric sockets	Important
12	Water seepage, delaminated tiles, discoloured tiles, and efflorescence	Important
13	Poor internal partition design and detailing	Important
14	Water dripping from air conditioner	Important
15	Specifying lifts with low passenger capacity (e.g., at peak hours)	Important
16	Inadequate sound insulation to reduce external noise	Important
17	Inadequate vertical circulation design	Important
18	Improper design of the ventilation system	Important
19	Inappropriate design, selection, and specification of rebar (reinforcing bar) and pipe	Important

4.1 Critical latent defects

The '*very important'* or critical latent defects and how they can be addressed or mitigated in the LPD scheme are highlighted next.

(i) **External pipes inconvenient for maintenance -** when external pipes are inaccessible or don't have a maintenance platform, this can make it difficult to perform necessary maintenance tasks, which can lead to failures and damage to the building. To address this, architects and engineers should design buildings that have adequate maintenance platforms and safe access routes for all external pipes. Through the LPD scheme, contractors and builders can ensure that these requirements are met during construction and that the building is designed to allow for safe and easy maintenance.

(ii) **Poor curtain wall design leading to difficult access for maintenance** - a poorly designed curtain wall can be challenging and costly to maintain. Architects and engineers should focus on designing curtain walls that are easy to access for cleaning and maintenance. This can include the use of removable components or other design features that allow maintenance personnel to access the area without major disruptions. The LPD scheme can help ensure that these design considerations are implemented during the construction phase, and that the proper measures are taken to make maintenance and cleaning of the curtain wall as easy and safe as possible.

(iii) **Inadequate working drawings and specifications** - when project specifications and working drawings are incomplete or incorrect, this can lead to construction errors, rework, and delays. Architects, engineers, and construction contractors should ensure that project specifications are complete, accurate, and properly reflect the building's design intent. Through the LPD scheme, building owners and other stakeholders can work together to clearly define project specifications and ensure that they are accurate and complete. Construction contractors can also use the LPD scheme to demonstrate that they have implemented quality control measures to ensure that project specifications are followed during construction, reducing the chance of errors or defects occurring.

4.2 Other common latent defects

Other common latent defects are discussed in this section. Generally, all the project stakeholders involved in the LPD scheme must play their respective roles to avoid these defects.

(a) **Inadequate space, size, and location of ductwork** - Properly sized and located ductwork is critical to ensuring that the HVAC system is operating efficiently and effectively. Architects, engineers, and HVAC specialists need to coordinate to ensure that the ductwork is properly sized and located based on the building layout and design.

(b) **Ignorance of materials performance** - Materials selection is an important part of the design process, and it is critical to select materials with appropriate properties for their intended use. Architects and engineers need to have a thorough understanding of material properties and their performance over time, considering factors such as weathering and aging.

(c) **Structural design is not flexible for future renovation** - The ability to renovate or modify a building in the future is an important consideration in building design. Architects and engineers need to design for adaptability and flexibility, taking into account future use and potential changes in occupancy and use.

(d) **Lack of parallel or cross ventilation in bedrooms** - Proper ventilation is important for maintaining good indoor air quality and promoting occupant health and comfort. Architects and engineers need

to design for adequate ventilation, taking into account local climate and occupancy patterns.

(e) **Foul odour transmission due to inappropriate positioning of kitchen and toilets** - Proper plumbing and ventilation design is critical to preventing the transmission of foul odours from kitchens and toilets to other parts of the building. Architects, engineers, and plumbing specialists need to coordinate to ensure that the plumbing and ventilation systems are properly designed and located.

(f) **Insufficient number and misdistribution of electric sockets** - Electrical design is an important consideration in building layout and design. Architects and engineers need to ensure that the electrical systems are properly sized and distributed based on the building layout and use.

(g) **Water seepage, delaminated tiles, discolored tiles, and efflorescence** - Proper waterproofing is critical in preventing water damage and deterioration of building materials. Architects, engineers, and waterproofing specialists need to coordinate to ensure that the waterproofing systems are properly designed and installed.

5.0 LPD implementation guidelines in high-rise residential buildings

The LPD scheme, as an innovative approach to design and construction, aims to eliminate waste, reduce costs, and improve efficiency while still meeting the needs and preferences of end-users. LPD is based on the principles of lean manufacturing and emphasizes collaboration between stakeholders, real-time iteration, and user-centered design (Awad et al., 2021). Furthermore, the LPD is considered as a promising approach for HRR buildings as the construction industry evolves. In this context, LPD adoption can help reduce waste, reduce costs, improve energy efficiency, resolve concerns about latent defects, and streamline the construction process while still providing the best possible results to end users.

Generally, the key factors to consider prior to LPD scheme implementation in HRR building development include (1) project type establishment; (2) potential users' characteristics based on their (a) willingness to adopt and pay for sustainable element incorporated into the design, (b) willingness to adopt sustainable design but not willing to pay on top market price, (c) likely to conduct major renovation - change original built-in components and other fixtures provided after occupation/purchase; (3) stakeholders' willingness to collaborate; (4) availability of cost-effective tools and techniques for real-time collaboration (e.g. end-user oriented communication platform); (5) willingness to embrace design for construction such as off-site construction, modular integrated construction and fabricated components; and (6) willingness to adopt technology such as use of building information modeling (BIM). Figure 8 depicts the flowchart for LPD adoption in HRR building development. The flow chart illustrates the stages involved in implementing LPD for HRR buildings, as well as the key issues to address at each stage.

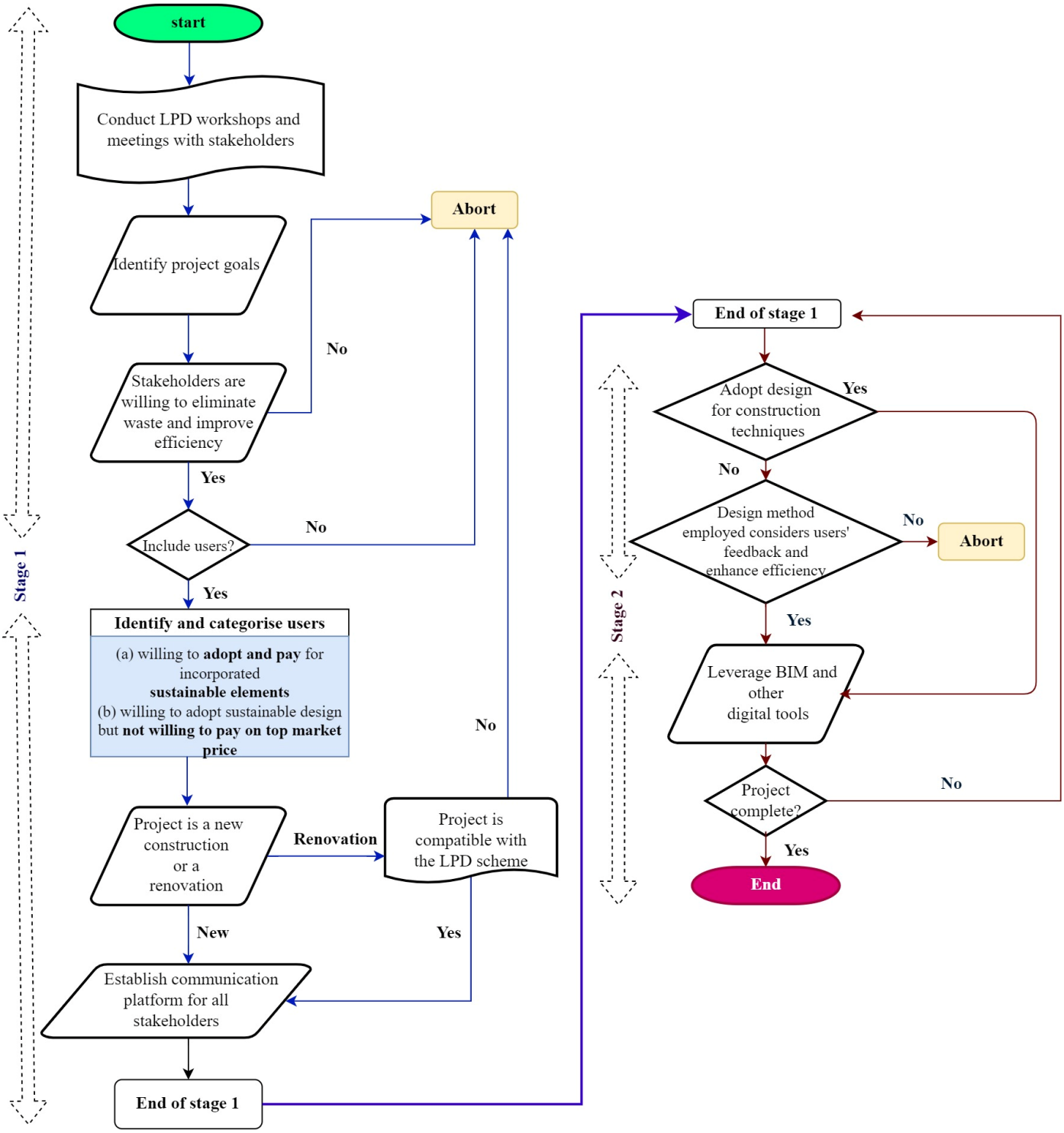

Figure 8: Guidelines for LPD scheme implementation

6.0 Conclusions

Implementing the LPD scheme in HRR building development has the potential to provide significant benefits such as reduced waste, increased efficiency, and improved user satisfaction. From setting project goals to incorporating user feedback and applying BIM and sustainable technology, the adoption process is iterative and collaborative. Project teams ensure that building projects are finished on time, on budget, and with minimal interruption to the surrounding environment (as it involves less materials waste) by implementing LPD in HRR buildings. Overall, LPD is a viable strategy that can assist the construction sector address growing needs while still delivering high-quality results to the end-users.

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