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# An Integrated Approach to the "Relife" of Office Buildings

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## ABSTRACT

Traditionally, decision making of building stakeholders when facing the alternatives is typically economically driven. This leads to the tendency to either delay refitting for as long as possible thus causing building conditions to deteriorate, or simply demolish and rebuild with least development cost mentality. With resource and sustainability considerations, the challenges of refit therefore re-life an existing building as opposed to new build will need to respond to political, social, environmental and financial implications. In reality however, few known projects have taken such holistic approach.

An Australian research was aimed at providing a more holistic approach to the decision making of relifing office building projects. Following a Delphi study to gather industry based evidence and research foci, the project engaged building stakeholders and researchers to explore four key areas of residual service life, recycling and waste management, floor space optimisation and construction project management. This paper introduces methodologies developed for the assessment, evaluation and problem solving in each area. It also discusses the case studies that helped produce best practice guidelines for integrated decision support when dealing with the relife of old office buildings.

**KEYWORDS:** Retrofit, Office building, Integration, Decision support

## INTRODUCTION

The significant growth in the construction of new commercial office buildings since the early 70's means that we now have a large stock of ageing buildings. This provides an opportunity for their efficient refurbishment therefore "re-life", rather than demolition and new build. At the same time, the increasing level of commitment to sustainability also encourages re-life options (CAR 2003 and Balaras 2004).

Traditionally, retro-fitting of office buildings have been done on ad-hoc basis. Owners, designers and contractors alike were often troubled by the poor building documentation and lack of reference to successful examples. As a result, designers may not foresee all of the potential problems while the contractors apply huge mark-up for having to deal with the risks. As these professionals begin to get more volume of work, the characteristics of these re-life projects and strategies to maximise the opportunities for technological, sustainable and economic solutions become important issues.

Previous research identified the needs for the total consideration of buildings structural assessment, modelling of operating and maintenance costs (Reyers 2001), new architectural and engineering designs that maximise the utility of the existing structure and resulting productivity improvement, project risks and their mitigation (Gray, 1999 and Skorupka 2001), specific construction management procedures including procurement methods, work flow and scheduling and occupational health and safety (Cox 2004). Recycling potential and conformance to codes may be other major issues (Faniran, 1998 and Nigel et al 2001).

This paper discusses a research project which investigated key issues within re-life projects. Issues that may impact upon the effective development process, such as the risk identification and mitigation, issues of decanting and existing tenants, condition of existing structure and services, demolition, waste and recycling, have been explored on an integral basis under four research strands. The most important ones were ranked by industry experts, tested against real life cases and categorised according to project development phases. Their inherent links were sorted through logical process integration. The resulting Best Practice Guidelines will provide valuable reference and decision making support to those involved in this type of projects.

## THE RATIONALE AND FOCI FOR RELIFING AGED BUILDINGS

Sandvido defines retrofitting as “the modification or conversion (not a complete replacement) of an existing process, facility, or structure” (1991). These modifications may involve additions, deletions, re-arrangement and replacements of one or parts of the facility. As a result, costs, quantity and types of services and products of the facility may be changed.

The significant growth in the construction of new commercial office buildings over the past thirty years means that we now have a large stock of ageing buildings providing an opportunity for retrofit or re-life rather than demolition and new build. At the same time, the recent focus and commitment to sustainability encourages retrofitting and re-life options. In Europe for example, the retrofitting market has experienced considerable growth over the past 5 years (Caccavelli, 2002). Several reasons can explain this paradox:

- User requirements have changed considerably during the last decade in terms of office equipment, communications, automation, quality of use and comfort;
- The past property crisis, which has affected many European countries, has amplified the stock of not rented office spaces: buildings that do not offer amenities for comfort and flexibility, are difficult to sell or rent;
- Costs of retrofitting a building is more or less half to one third of the cost of demolition and reconstruction;
- Office buildings are classified amongst the buildings with highest energy consumption (e.g. annual energy consumption in European office buildings averages 100-1000KWh/ $m^2$ of conditioned floor space).

In Australia, re-life of buildings is expected to form an increasing proportion of the annual capital budget with some estimates being as high as 50%. This has important implications for sustainability. If the Koyoto targets were to be reached, it is the existing building stock and their efficiencies which must be improved. Waste minimisation and recycling can also form a significant part of the equation, accounting for an estimated 0.5% of GDP. An exemplar project in this area is the lead of the national WasteWise construction program which has already decreased the amount of waste going to landfill by 90%. The pressure for all retrofit building projects to follow suit is mounting.

While the potential of this market sector is evident, there remain some challenges of the re-life option as opposed to new build such as:

- Decisions on political, social, environmental and financial implications of re-life compared to new build (Balaras 2004);
- Feasibility studies assessing the condition of the existing building, the residual service life, and estimating construction costs, modelling of operating & maintenance costs, and the utility and productivity expected from the refurbished building (Reyes 2002, ECI 2003)
- Architectural and engineering design to maximise the utility of the existing structure (Thomas et al 1996).
- Coordinated work scheduling for clients, consultants and contractors in terms of forward capacity and production planning linked with design, procurement and decanting schedules.
- Additional challenges for demolition and waste handling and disposal, potential recycling, occupational health and safety, condition surveys and identification of services etc (Nigel et al 2001).

Effective decision making will also need more data and modelling of different scenarios to allow comparison of the alternatives. Largely due to the lack of as-built on old buildings, information on the modelling of operating and maintenance costs, the utility and productivity expected from the refurbished building, and the monitoring of building energy performance depending on the alternatives is particularly hard to come by.

Nevertheless, these phenomena and evidence imply that there is a new market developing which not only requires attention but also application tools that can help stakeholders making decisions such as:

- Sustainability issues including indoor air quality, energy saving, waste handling, disposal, potential recycling and Occupational Health and Safety (OH&S);
- Conditions of existing buildings and the residual service life;
- Waste management issues and recycling potential;
- Associated risks, costs, time and project delivery patterns and project management processes.

Earlier research around the world explored methodologies and software tools for the assessment of a building's existing structural conditions, energy usage and estimation of costs.

EPIQR and MEDIC are software with structured diagnosis scheme covering the state of degradation of building of existing residential buildings, energy performance and indoor air quality in order to help users make informed decisions (Flourentzou 2000). TOBUS is an evaluation tool for the assessment of retrofitting needs of office buildings in European countries and for estimating the costs to meet these needs in compliance with sustainability issues such as energy performance and indoor environment (Caccavelli et al, 2002). Office Scorer is a tool developed by the Building Research Establishment (BRE) in the UK in 2002 to systematically compare and test the environmental and economic impacts of different building design concepts for offices. BRE has modelled a number of buildings over a 60 year life and evaluated the economic and environmental impacts of a range of factors including building elements degradation, ventilation and cooling system energy saving (BRE and dti 2002).

In the US, software called the Facility Energy Decision System was developed by the Pacific Northwest National Laboratory to inform decisions on energy-saving retrofit projects (FEDS 2004). In Australia, the Building Division of the Queensland Department of Public Works developed the Ecologically Sustainable Office-Fitout Guideline as a strategic asset management framework. It covers key aspects of community, energy, material and water in relation to office building fitout works (Queensland Government 2004).

These methodologies and tools provide the global view and focus shift to building's renovation and refurbishment processes. Some enable users make informed decisions in targeted specialty areas. However, most of the tools approached the building refurbishment issue in an ad hoc basis and tend to deal with specific issues within a region. Over reliance on computer programming development may render these tools to become inflexible, unadaptable and non-updatable. Therefore, there is an urgent need to develop a more integrated and holistic tool that operates in a scientific and procedural manner. In particular, knowledge gaps need to be covered in residual service life, waste management, floor space optimisation, project risk assessment, contractual issues and procurement patterns.

## THE INTEGRATED APPROACH

To respond to the challenges discussed above and to provide decision making assistance for clients, consultants and contractors involved in the relifing projects, a research project was developed and recently completed in Australia to explore integrated approach to dealing with issues impacting on re-life projects, design, engineering and procurement, and issues of decanting and sustainability. The research also developed decision-making support mechanism for assessing the condition of the existing building structure, residual service life and floor space optimisation,

The project objectives are to investigate the characteristics of re-life projects that impact upon the effective management of the construction process, such as the identification and mitigation of risks, issues of decanting and existing tenants, identification of existing structure and services, work scheduling, occupational health and safety issues for construction personnel and tenants, demolition, waste and recycling, issues of quality and workmanship, cost planning and cost modelling methodologies. Based on a comprehensive literature study, it embarked on a path of Delphi study, Process Integration, Case study and Industry interviews, before extracting and presenting information through the development of decision support tools (Figure 1).

### The Delphi Study

The Delphi Questionnaire was designed to allow a panel of industry experts to determine the most relevant and important issues of consideration of refitting commercial office buildings. The process of determination involved four rounds of surveys using electronically mailed questionnaires over a period of 4 months, during which the industry experts were asked to consider, and reconsider, the relative importance of issues presented for consideration, particularly taking on board feedback from peer reviews. A unique aspect of the Delphi Questionnaire is that the industry experts consider the issues individually, without discussion with other experts (Chan 2001). These issues were considered in five categories:

1) Sustainability & Building Efficiency,
2) Project Management,
3) Residual Service Life,
4) Recycling & Waste Management, and
5) Floor Space Optimisation.

Prior to Round 1 of the Questionnaire in Delphi Study, a mind map of issues was identified through a comprehensive literature study, discussion with project team members, and a pilot study with a real-life case. As a result, 49 issues were initially identified and incorporated into the Delphi Questionnaire. The Delphi Questionnaires were sent to 13 industry experts and were asked to consider the issues on a 5-point scale. Between 9 and 13 responses were received for each of the four rounds, and the experts re-evaluated their choice, ranking, and weighting of issues in consideration of the overall ranking as suggested by their peers.

After Round 1, the number issues grew to 68 as 19 new issues were proposed by the panel of experts. The highest, the lowest, the mean and the deviation of scores for each of the issues were analysed so that the new order of issues and their "relative importance" could be established for the next round of study. The highest ranked issues and their average scores were also evaluated and compared between rounds to identify swing of opinions and affirm reliability of the information.

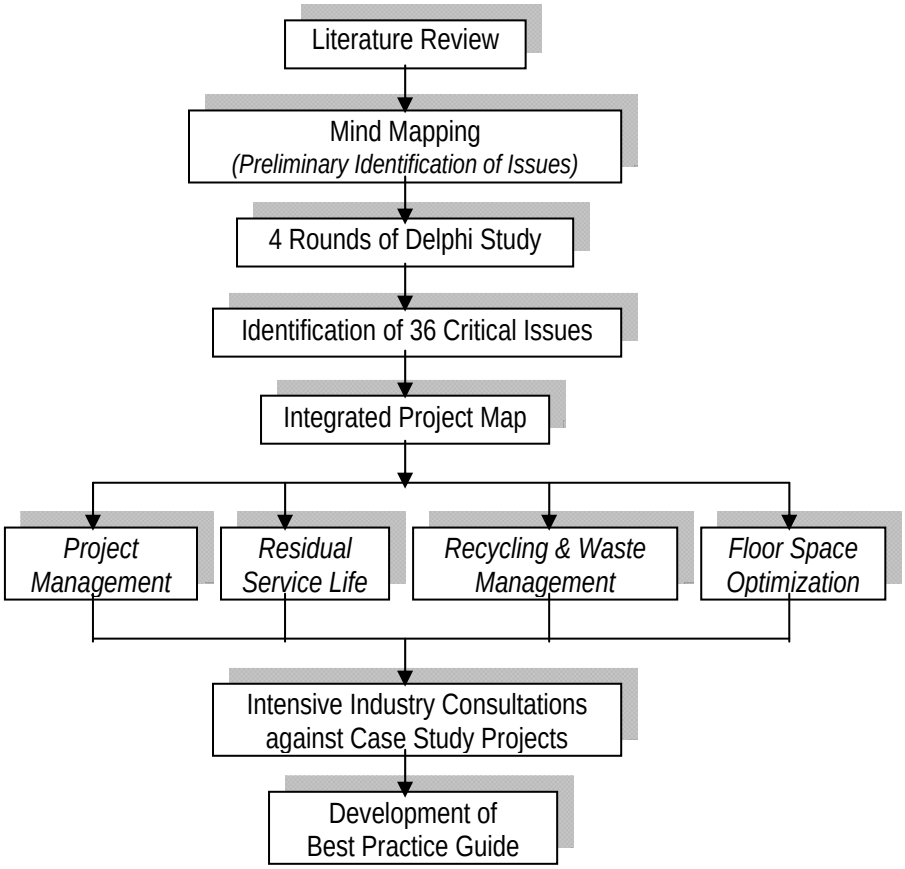


Figure 1 Research Development Process

Following the Delphi study and subsequent industry interviews, a total number of 36 critical issues relevant to retrofitting of office building projects have been revealed. The five top ranking critical issues are purpose of refurbishment, energy saving potential, cost analysis for sustainability and building efficiency, project cost risks and condition assessment. As Sustainability and Building Performance was the primary goal of another

research project funded by the same agency, this research concentrated on the other four categories, or research strands. At the completion stage, cross reference to the Sustainability research project was made.

**Development of Integrated Project Map**

The 36 critical issues were examined and articulated. The research team developed an integrated mapping of these issues according to six major phases of project development, therefore providing the integration among issues of all four strands. While six project development phases were considered, the research was able to extract knowledge for and cover the decision making patterns of four phases including Conception, Feasibility, Design and Procurement. Due too the lack of completed projects for verification, the phases of Construction and Operation have not been fully covered. Result of this integration process is discussed in the next Section.

**The Case Study**

Three real life refurbishment projects have been identified and used as case studies in this research.

The first is a project in which two adjacent high-rise office buildings were integrated through the refurbishment. The main focus was to provide a consistent level of amenity, fitted out with new interior finishes and office accommodation, complete with all engineering services required to produce a building which meets the Government's present energy targets for sustainable development. Project management issues such as market demands by types and location, procurement of contract, decanting, workplace health and safety issues, management of tenants etc were explored mainly from this project.

The second study focuses on a medium-rise commercial building approximately 35 years old, which comprises of seven office levels and four car park levels. The building structure composes of reinforced concrete slab supported on secondary and primary beams and concrete encased steel columns. The design team of the building proposed three preliminary design options to satisfy the client's needs. This project has been used for analysing those options and developing possibilities to maximize floor space which could be included in the options proposed by the design team. Strengthening of existing structure of the building due to the optimization of floor space is required and those data have been used to validate the matrix of mapping solutions to problems.

The third study was on the refurbishment of a 30 year old building, with twenty storeys of office floor space plus a small basement car park. It is jointly owned by two levels of government for a variety of mixed use. Because of the nature, different refurbish options and levels of work were proposed by the design team and the building remained operational throughout the refurbishment period. This project was primarily used to study waste management and reuse of building materials.

Frequent site visits to the three case study buildings had been conducted and researchers were able to collect and exchange data for their

respective strands. Data collected were later used to check the robustness of outcome of this research and to validate the linkages identified at the development stage.

## RESEARCH FINDINGS

With the sustainability Issued covered by another project under the same funding regime, the research reported here completed four strands concentrating on respective issues as discussed below. Relevant deliverables such as process integration mapping and best practice guidelines are also discussed below.

### The Four Research Strands and Key Findings

Project Management: ten issues critical to the management refurbished projects are nature and scope of work (objective & market research), type of contract, market demand by location and type, perception of tenants, pre-commitment by tenants, key project risks (cost, quality and schedule), decanting, workplace health and safety issues, modifying existing documents and management of tenants. The design team has to bear in mind of client's/tenants' needs. Communication and understanding between project stakeholders are important to ensure smooth implementation of the project. Guided decision support will be required for project stakeholders.

Residual service life: to evaluate remaining service life of specific components, assessment of the current degradation state or functional use and the future patterns of degradation is important. State-of-the-art methods on residual service life estimation appear to be mostly conceptual and need significant forms of data. Seven key variables identified are condition assessment, defects – structural, defects – functional, status of structural health, life of elements and components of the building, performance monitoring and security. These variables were analysed and compared with other buildings in developing a generic approach. Residual service life methods have been established to determine the underpinning factors.

Recycling and waste management: there is a widespread willingness among office building professionals to operate more sustainably. However this should be met with targeted guidelines for project stakeholders. Specific building materials where recycling rates are variable across the states need to be identified and 'state of the art' recycling information dispersed to all contractors. Secondary markets for reuse of components such as sinks, basins and cupboard need to be encouraged by state governments, whereas asbestos material needs to be addressed in detail, so that all waste from such buildings is not automatically directed to landfill.

Floor space optimisation: the crux of the issue here is the maximisation rentable floor space. Options available to the client in maximising floor space include removal or addition of floors and partitions, relocating services, cutting openings and relocating lift wells etc. In these situations, innovative structural strengthening schemes could be implemented to strengthen the existing structure after an initial structural appraisal. Five critical issues identified are structural appraisal, structural safety, structural strength, change of use of floors, relocate/renew services. Typical design examples and calculations were developed for reference.

**Integrated Decision Support**

While many issues need to be amplified within their disciplines and knowledge areas, their integration along the path of project lifecycle is very important for holistic consideration and problem solving. To this end, the research team developed Process Integration Mapping which linked the 36 issues with logic, order of execution, cross-reference, and quality control in mind, along the continuum of project development phases. Figure 2 shows an example of some of these issues that need to be handled in the Project Conception phase.

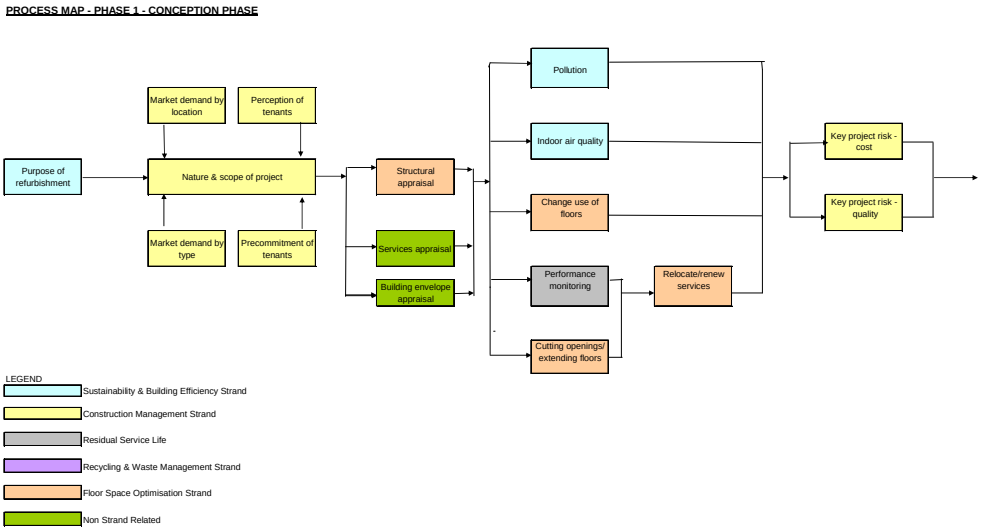


Figure 2. An example of the Process Map with Critical Issues Integrated against Project Development Phase (Conception phase shown)

**Best Practice Guide**

One of the research deliverables is the Best Practice Guide that encapsulates the relevant problem solving logic and knowledge for decision making on all 36 issues. Figure 3 shows one of the 36 issues, Nature and Scope of work (market research), with the best practice guide developed into a decision assistance module. The knowledge and information is organised according to (1) the potential causes for this issue, (2) the problems it will bring about, (3) the possible actions that can be taken, and (4) the results from such actions. The top part of the module presents graphical linkage between these elements, depicting the inherent relationships. The bottom part further elaborates "what-to-do" actions of these elements according to the related project development phase.

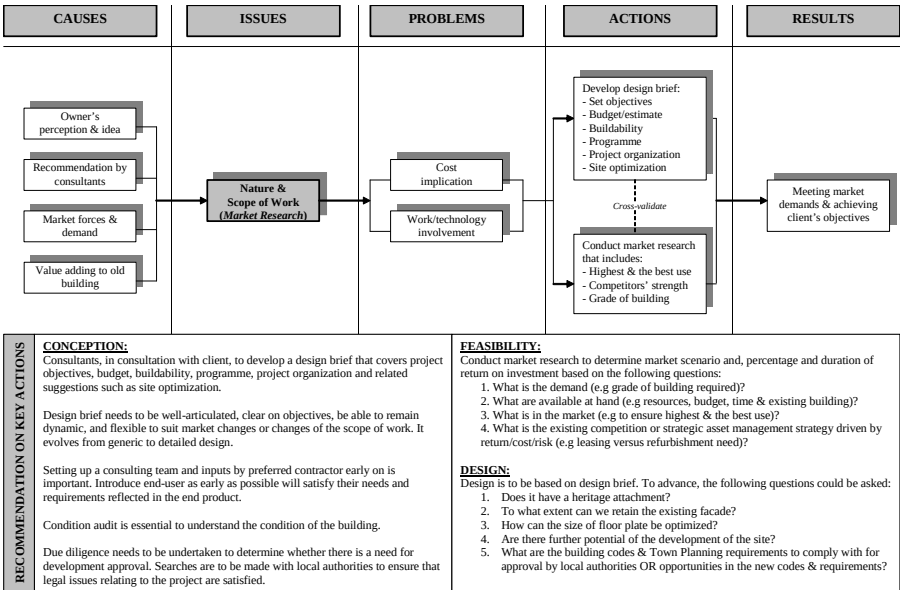


Figure 3 An example of the output module of the Best Practice Guidelines

The researchers conducted a validation process by cross-checking the Best Practice Guide against real life projects and by consulting with professionals in facility management, architectural design, demolition, contracting, and project management. The Best Practice Guide was considered highly valuable especially to project partners for guided decision-making assistance when contemplating alternatives of retrofitting projects. In particular, professionals confessed that while they have in-depth knowledge in one or more areas, they may not be able to consider and cover all of the areas. The Best Practice Guide can provide building owners, developers and contractors a systematic tool to evaluate potential projects holistically, rather than make hasty decisions on demolition and build new buildings, thus avoiding unviable technological, economical and

marketing outcomes. Based on this feedback, efforts are being made to convert the Best Practice Guidelines into a check list format.

## CONCLUSION

In the wake of increased demand on refitting offie buildings and pressure to respond to sustainability challenge, the timely issue of decision making and knowledge support for these type of projects was discussed in this paper,

In dealing with the complex issue of relifing throughout the project lifecycle, industry opinions were firstly sought in this research. Combined with the researchers' independent input and findings of literature study, these perceptions were tested and filtered through a Delphi study and real-life project scenarios. The confirmed opinions were consolidated to current knowledge that meets industry expectations. They were then extracted and incorporated into the development of decision-making tools such as the best practice guidelines. These tools provide an integrated and consistent way of examining the whole of life issues for buildings intended for refurbishment, thus avoiding ad hoc decisions made in isolation by individual stakeholders.

On-going research will be needed to cover issues identified for the development phases of Construction and Operation. Comparisons and cross-referencing with research from other regions will also be beneficial. With the widespread use of the internet, modules of the Best Practice Guide can be presented as web-based reference tools. This will also help raise the profile and public awareness on the importance of relifing projects.

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