A framework for refurbishment of health facilities

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A FRAMEWORK FOR REFURBISHMENT OF HEALTHCARE FACILITIES

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ABSTRACT

Demolishing existing facilities and constructing new facilities is not a feasible solution to provide modern healthcare services and reducing the impacts of healthcare construction industry on the environment. Also, the National Health Service’s (NHS) focus on new construction in the recent past is responsible for the deteriorating existing building stock. An investigation of healthcare refurbishment reveals a need for a specific framework for existing buildings as the characteristics of new facilities and existing facilities are not similar. The function of the framework should be to assist with the refurbishment process. The research attempts to discuss current trends in refurbishment of healthcare facilities and possible solutions for the same. The methodology used is a literature review, web-based case studies, interviews, and observation site visits to several hospitals. A conceptual framework for refurbishment is proposed in the remainder of the paper. This work is a part of a research project related to existing healthcare facilities with energy as a key focus. It is identified that research in the area of refurbishment of existing hospitals has been neglected despite existing hospitals accounting for a significant portion of the NHS’s healthcare buildings stock.

KEYWORDS

Energy, existing healthcare facilities, NHS, refurbishment, tools

INTRODUCTION

A significant amount of non-domestic buildings which will be standing in 2050 have already been built (Davies, 2009). Furthermore, the overall existing building stock remains largely untouched, replaced at slow rate, and many recent refurbishment projects have missed the opportunity to reduce emissions and carbon footprint (Carbon Trust, 2008). Recently, the research community has started to focus more on non-domestic buildings such as hospitals, offices, and superstores which are considered to be the most energy intensive buildings. Also, the growing importance being given to the existing facilities is in part due to

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increased recognition of ‘whole-life cycle cost’, economic efficiency, environmental impact, and sustainability (Kapoor et al., 2006, Monts and Blissett, 1982). The reason behind more consideration being given to ‘whole-life value’ as opposed to initial construction costs is emphasised by a buildings’ impact on the environment throughout its life-cycle. Until recently, the focus of healthcare construction has been on the development of new healthcare facilities with existing facilities being given greater attention in recent years (Sheth et al 2008). Also, it is reported that most hospitals today still fail to make patients feel comfortable (Lubell, 2008). Many new and recent healthcare buildings do not demonstrate sufficient high quality performance (Mason, 2006). Often, existing facilities are demolished, left untouched or undergo a change of use.

Although in the past some studies related to energy consumption have been completed such as Pedrini et al (2002), Chirarattananon and Taveekun (2004), Pan et al (2006), Neto (2007), etc. they are focused on general types of buildings and not related to existing healthcare facilities. Whereas, studies related to energy consumption by Yik et al (2001), Jenkins and Newborough (2007) focused on commercial buildings such as hotels, and Gieseler et al., (2004) focused on housing. Also, the studies by Adderley (1988), Lonnberg (2007), Yoshida et al., (2007), etc. relate to energy consumption of hospitals but they are not focused on refurbishment or existing buildings. The study by Lonnberg (2007) focused on energy saving possibilities using variable frequency drivers (VFD) for hospitals but lacks focus on design and physical built environment aspects of facilities.

Thus, this research aims to identify characteristics of refurbishment for existing healthcare facilities. The project is related to research into refurbishment of existing healthcare facilities with energy as one of the key parameters. This is a partial output of primary and secondary data collection as part of a three-year research project. To accomplish the research objectives, a literature review along with interviews and web-based case studies were conducted. In this paper, facilities considered for refurbishment and/or extension are discussed.

There has been a recent increase in applications of Building Information Modelling (BIM) and simulation based tools for speedy delivery of construction projects which have been considered within the scope of the reported study. In the following section, the research method is presented followed by a literature review including web-based (online available) case studies. With the help of secondary data collection, interviews, and web-based case studies, a framework for refurbishment was developed based on various approaches adopted during recent refurbishment projects. The information presented in Section 1 is supporting information for a conceptual framework presented in the remainder of the paper. The conceptual framework is subsequently proposed based on the
findings from primary and secondary data collection. The final section of the paper presents a discussion and conclusions.

**RESEARCH METHOD**

Following secondary data collection (via a literature review and web-based case studies) progress was made gathering primary data using a questionnaire survey; interviews with practitioners; and observations during various site visits. The aim behind the primary data collection was to corroborate findings of the secondary data collection. Also, the primary data collection helped to develop a better understanding of how refurbishment projects are implemented within the industry. The key objective behind the review was to identify practical approaches and shortcomings in the existing practices.

As part of the data collection, 43 questionnaire responses, group and individual interviews, and five site visits were conducted. Considering the limited time frame and other research limitations (such as budget, resources) face-to-face interviews were conducted in the UK and an email-based questionnaire survey was used to reach the participants from the UK as well as USA. The email-based questionnaire helped to reach the selected audience irrespective of their location. During data collection stage the researcher contacted 250 registered architects with American College of Healthcare Architects (ACHA) and collected 35 responses from the USA; eight experts working on Private Finance Initiative (PFI) and NHS projects from the UK responded out of 60 selected for the survey. Also, 33 experts were contacted to conduct face-to-face interviews of which 11 interviews (with seven individuals and a group of four experts) were undertaken in the UK. Also, five site visits were made to ongoing refurbishment projects with the help of the interview participants. This helped to explore refurbishment and to experience the level of noise, construction dust, etc. with ongoing refurbishment projects.

To collect primary qualitative data, all the questions were open ended as suggested by Knight and Ruddock, (2008). The collected data was analysed manually and presented in this paper. With the help of spread sheets the raw data was categorised for the ease of analysis. Categorising the data helped to develop conceptual schemes within the data which provided background information in the development of framework. The use of a spread sheet proved to be useful during analysis to organise the raw data. The names and types of categories were derived with the help of literature, professional reading, and the information provided by the participants. Also, the development of a protocol to conduct interviews and a questionnaire survey helped to organise and categorise the data. To conduct interviews and a questionnaire survey the protocol comprised of three key sections was developed. The three key parts of the protocol were: a background section; a section on current trends in refurbishment with special
focus on energy and carbon emission; and a section for feedback, comments related to refurbishment, research project, and client and government policies. The protocol was developed with consideration to principles of qualitative data and tested using a pilot study. During the pilot study a questionnaire was sent to seven selected responded who agreed to participate in the survey. Also, the protocol was discussed with the researcher’s supervisors and three colleagues with different backgrounds from the researcher’s department before conducting the interviews. After the pilot study a revised questionnaire was sent to rest of the participants as discussed further.

Quantitative research is uni-dimensional whereas qualitative research is diverse (Knight and Ruddock, 2008) which helped to explored more key areas within the boundaries of the research. Within the scope of the research, it was very important to investigate how refurbishment projects are executed and the quality of those research projects rather than knowing how many refurbishment projects are executed. Also, during initial stages of investigation it was clear that refurbishment of existing facilities is very important, but the level, scope, and boundaries of refurbishment projects were not clear from the literature review. Thus a qualitative research methodology was employed as the data collected using qualitative methods is more detailed compared to quantitative methods (Brewer, 2007). Subsequently, the data was analysed to identify goals, objectives, drivers, and challenges related to refurbishment in the healthcare sector. Furthermore, in this work Leadership in Energy and Environmental Design (LEED), NHS Environmental Assessment Tool (NEAT), Building Research Establishment Environmental Assessment Method (BREEAM), etc. building certification tools are considered briefly as the research aim is not to develop another certification tool, but to integrate and/or to interface with existing tools. In this work, procedures from the literature and discussion of data collected during interviews are compiled together followed by a proposed conceptual framework to use during refurbishment. The web-based case studies, literature review, and interviews were used as a basis upon which to develop the conceptual framework.

**PRIMARY AND SECONDARY DATA COLLECTION**

On average an acute-care hospital consumes significantly more energy compared to a commercial office building of same size because of its round the clock operating schedule, air quality regulations, and clinical equipment etc. (Cassidy, 2010, Hirst, 1982). Furthermore, many existing hospitals are energy inefficient and need to be considered for energy refurbishment which may require improvement of the external envelope (CADDDET et al., 2005). A case study of The Villa Street Medical Centre in London reported that “restoration and refurbishment are challenging but can bring derelict buildings back to life”
(Mason, 2006). Traska (2007) explained refurbishment as “plastic enough to adapt to local need and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites.”

The current target for the NHS is to reduce carbon footprint by 10 per cent by 2015 compared to a 2007 base line (NHS, 2008). The European Parliament indicated a significant possibility to reduce energy consumption in existing buildings (Bizzarri and Morini, 2006). However, it will be difficult to achieve the carbon emissions target set by government if existing buildings miss the opportunities to reduce their carbon footprint during refurbishment (Davies, 2009). If refurbishment is considered appropriately with all other services in place, then existing infrastructure can be considered as an asset and feeder for a new development. A recent study by Traska (2007), related to designing renovation, reported that it is very important to engage 3D simulation and material prototypes for a complex project to test the performance of the emerging object.

1.1 Drivers for healthcare construction sector

Considering the size and scale of healthcare facilities, refurbishment can arise at any time because of various below mentioned reasons. The Community Hospital of the Monterey in Peninsula, California was upgraded and expanded several times before considering for major refurbishment after 50 years from inception of the facility (Lubell, 2008). The West Suffolk Hospital in London was refurbished because of development in clinical treatments and services (Astley, 2007). In some old buildings the presence of asbestos is considered as a driving factor for refurbishment and needs to be removed during refurbishment (Racine, 2010). A facility operating at full capacity may demand refurbishment sooner than other facilities which are not occupied to their maximum limit. For example, the Mental Health Care in Birmingham has been re-decorated three times over 11 years due to operating at full capacity (Mason, 2006). During the redevelopment of Meyer Hospital at Florence in Italy, four distinct areas were considered to reduce energy consumption and improve indoor air quality: insulation; energy saving and recovery; natural ventilation; and the building management system (BMS) (Gallo and Stefano, 2006). During an interview, design team members mentioned aging infrastructure is a key reason for the redevelopment scheme in the North-West of the UK. Also, it was mentioned that round the clock running nature of hospitals impose various challenges during redevelopment. The redevelopment scheme was to construct new facilities for clinical purposes and use existing facilities for administrative purposes. Also, there can be additional drivers depending on the Department of Health’s (DoH) policies and agenda. There can also be several drivers related to sustainability as presented by Manoliadis, (2006) which are categorised further into construction,
administrative, and legislative drivers by Sheth et al (2008) in addition to drivers related to energy to achieve overall sustainability. Also, there can be additional drivers based on individual NHS Trust strategies and/or the design team strategy specific to a project. Furthermore, the drivers can be classified into strategy drivers and drivers based on principles, priority areas, and commitment presented by Sheth et al (2008).

1.2. Challenges for healthcare construction sector

Structure, form, and orientation of existing buildings are particularly challenging in refurbishment projects, compared to construction of new facilities. For example, during refurbishment there is very limited scope to re-orient the building; orientation should still be considered wherever possible. There are various ways to re-orient buildings, such as re-planning existing layouts or internal spaces such as lobbies and waiting areas, and reducing energy consumption by making maximum utilization of available day light. For example, a visitor’s waiting area or reception/entrance can be re-located where it can receive natural day light, achieve improve indoor air quality, and is easy to access.

The West Suffolk Hospital refurbishment project in London had several physical challenges for refurbishment including low ceilings, external load bearing walls, inflexible supply systems, and overcrowded facilities (Astley, 2007). During the refurbishment of hospital services diversion can be challenging and impose additional limitations on refurbishment projects (NJHA, 2009). Considering existing building stock owned by the NHS, a building’s historical value which cannot be altered may impose some challenges during refurbishment such as the re-development of the Royal Hospitals site in Belfast, and refurbishment of St Nicholas's Hospital in Great Yarmouth, UK.

During refurbishment of the Southend University Hospital in Rochford, the adjacent buildings were occupied, and access for construction was gained through the existing elevation with some modification (Laing O’Rourke, 2006). Nevertheless, existing buildings often suffer from a lack of as built /modified information such as drawings, plans, and operation and maintenance manuals. The Chiddenbrook Surgery in Exeter Devon, reported inadequate natural ventilation in summer (Reynolds, 2007). Other than the above mentioned challenges, there can be additional project specific challenges due to location, design, goals, objectives, and scope of work depending on the project brief.

1.3. Refurbishment aim, objectives, goals

As part of this research not only academic literature was used for secondary data collection, but also published case studies from books and the internet. In this
section data gathered from the case studies and interviews are compiled to demonstrate the refurbishment process. The interviews and primary data collection helped to cover gaps in the literature review. Table 1 shows a list of points for consideration, followed by objectives and goals for refurbishments based on the data collection are presented. This is an output from the primary and secondary data collection, and is generated on the basis of learning from various projects as reported by interviewees and literature.

Table 1: Points to be considered during refurbishment

<table>
<thead>
<tr>
<th>For refurbishment</th>
<th>For existing buildings and users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Communication between the design team, hospital staff, patients, and users is important.</td>
<td>1. User is aware of at least the next 10 construction moves/activities.</td>
</tr>
<tr>
<td>2. The use of BIM is suggested but should not be dominating.</td>
<td>2. It is difficult to locate mechanical services and utilities; be ready for surprises.</td>
</tr>
<tr>
<td>3. Any planned construction activity away from and with consideration to patients’ rooms will help the smooth running of a project.</td>
<td>3. There might be harmful fumes, gases released (e.g. at roof level) from existing building in use, which can affect ongoing work.</td>
</tr>
<tr>
<td>4. Provide details about where the construction team will be working.</td>
<td>4. Conduct a pre-investigation before starting any works.</td>
</tr>
<tr>
<td>5. No phasing plan is perfect, and there might be challenges to execute planned activities.</td>
<td>5. Be prepared to have back-up equipment to support running of mechanical plant.</td>
</tr>
<tr>
<td>6. Because of obstruction to existing users, be prepared to accept some unforeseen problems.</td>
<td>6. In some cases there may be a need to work with minimum available clear height, space, or time.</td>
</tr>
<tr>
<td>7. No scope of work for refurbishment is perfect.</td>
<td>7. Always carry out an investigation on completion of work, irrespective of scale of work.</td>
</tr>
</tbody>
</table>

An investigation revealed the following minimum objectives to be considered during the refurbishment and designing of a new healthcare facility. These objectives are based on the partial refurbishment of Waitakere Hospital in New Zealand (Fullbrook et al., 2006), several case studies published by the Commission for Architecture and the Built Environment (CABE) (Mason, 2006) and various web-based case studies, among others. The objectives are divided briefly into two parts; objectives related to design, and those related to construction.
Objectives related to design.

1. Provision of good public open spaces (waiting areas) and out of hours community use.
2. Good integrated design and a clear plan with clear circulation.
3. Incorporating natural lighting (maximum use of day light), natural ventilation, and consideration to energy efficiency.
4. Ample storage space, flexibility, and adaptability to make a facility future proof.
5. Improved performance when compared pre and post project performance results.

Objectives related to construction.

1. Consideration to users (patients, visitors, and staff).
2. Effective communication between design team, client, and users.
4. Sustainable (environment friendly) material and finishes must be considered.
5. The waste generated during the construction/refurbishment process must be disposed of safely.

For the success of any project it is very important for the members to share the same goals, follow minimum project objectives, and work as a team. During data collection one interviewee mentioned that due to the introduction of a company policy related to sustainable procurement; they had to reject many (almost 60 per cent) pre-approved company contractors. The research has revealed some minimum goals for existing buildings to be considered during refurbishment and/or throughout the life-cycle:

1. Consideration to overall sustainability.
2. Strategies and polices to minimize the energy usage.
3. Corporate commitment to cut down carbon emissions.
4. Ensure that facilities are operating efficiently during refurbishment.
5. Reduce dependency on crisis-management with a well planned programme.
6. Reduce the frequency of component failure.
7. Ensure facilities are maintained to comply with the health and safety regulation throughout refurbishment process.
8. Provide public transport access to the hospital to reduce car travel and need for a car park.

Effective project management is a key factor for successful refurbishment. All the above mentioned points can help to form a project’s aim, goals, and objectives. These points should be used while developing a refurbishment proposal for any
existing healthcare facilities. Later, a conceptual framework is proposed which can be used to accomplish a project aim, goals, and objectives. The framework and above mentioned points should be used as a baseline or guidance during any refurbishment project and, there can be additional objectives depending on the specific requirements of a project.

DISCUSSION OF INVESTIGATION

In this section a refurbishment process is explained with the help of collected data. A hypothetical refurbishment process based on several real life examples, literature, and case studies is presented. The process helped to propose the framework in the following section. The investigation revealed that for successful refurbishment of healthcare facilities the first step is to develop a business case. For example, the business case for extension of Royal Devon and Exeter NHS Trust in Exeter, UK compared three possible solutions: do nothing, refurbish, or build a new 24 station dialysis unit. The comparison revealed that the refurbishment option was cheaper than a new construction (Reynolds, 2007) and helped to validate the business case.

Followed by the business case, a master plan should be developed. A proposed master plan during refurbishment for Dell Children’s Medical Centre on a brownfield site in the US (Cassidy, 2010) and during partial development of Waitakere Hospital in New Zealand (Fullbrook et al., 2006) helped both the projects. Although there was a lack of a design brief at the beginning of the Waitakere Hospital project, having a definite goal to present an ‘Eco-Hospital’ helped to develop a master plan. Similarly, during the research, the Belfast NHS Trust, explained that the development of a complete master plan can be beneficial and existing infrastructure can prove to be an advantage more than limitation if, considered effectively. The preparation of a master plan establishes the overall look of the facilities/premises and it can be in accordance with changing technologies which permits further upgrading. A proposed and phased master plan for hospitals can focus on areas that need renovation, design assistance, and complete refurbishments in near future. The plan also allows hospital managers to accomplish renovation objectives. Creating a master plan involves making an overall assessment of interior as well as exterior problems along with outlining possible solutions, estimated project costs and facilities performance, and developing a project plan.

While developing a proposal it is important to preserve the existing character of the campus and the buildings especially if the hospital campus is very old with some heritage buildings on the site. The existing buildings can be used effectively if, positive and negative points of these facilities are appropriately considered. Additional information related to occupancy (evaluation) and use of the building along with involvement of energy and/or facility managers will help to predict the
energy consumption. At this stage detailed surveys related to the facility will help to highlight the priority areas to plan the future activities, and to decide the scope of work.

Early modelling of a building’s energy use is an important approach considering the condition of fabrics and envelope (floors, ceilings, walls, windows, and doors) of the building which can benefit refurbishment. While designing the Centre for Health and Healing in Portland, USA simulation studies were used (Gragg, 2007); these estimated that the building would use 61 per cent less energy than specified in the energy code. However, in reality the energy consumption was more than estimated because of inadequate inputs related to operational hours of the building to the energy model (Gragg, 2007). Also, before accepting or rejecting any strategy or feature, especially related to energy saving and design, alternative options should be considered and assessed. This approach will help to validate the proposal as well as to minimize facilities impact on the environment. Although primary consideration should be given to the thermal performance of envelope, a technical survey related to the existing building’s condition and post occupancy evaluation is very important (Carbon Trust, 2008).

To achieve successful commissioning for energy efficiency, all the activities must be planned well ahead and should not be allowed to slip. During the key stages of the development of a refurbishment proposal, simulation should be used to assess the performance and ensure that proposal will meet the design goals. For example, in the Ambulatory Care Building of a Children’s Hospital in Canada it was observed that the lobby can get hot and stuffy because of very low air flow on very warm sunny days (Phillips, 2004) which clearly indicates a lack of simulation studies or prior studies related to building form, internal heat gain, and orientation. During data collection one interviewee mentioned that “no former pre refurbishment building survey was done and now no one knows what is inside the wall”.

As part of the process, the plans should be turned into a BIM model (Day, 2010), for example during extension of Anderson Cancer Centre in the US a BIM model was developed from existing computer aided drawings (CAD) (Schneider, 2010). The reason for extension of the Anderson Cancer Centre was unpredicted demand where 12 storeys were added on the top of the existing 12 storeys towers. The model helped throughout the project and to speedup construction. The Akershus University Hospital in Norway was created using Industry Foundation Classes (IFC) and a BIM model to plan mechanical services, mechanical equipment related activities, and for visualisation (Building Smart, 2008). The same model was used for quantity take off, energy calculations, and other simulation studies. For better understanding and visualisation of healthcare facilities a BIM model is reported as very useful tool and can convey the design team message to end user
BIM model can help a team member from non-architectural background to visualise the end product (facility). Not only AUTODESK (one of the leading provider of various BIM based tools) has reported benefits of BIM but also, industry and various experts such as Schneider (2010), Cooper (2008), Fullbrook et al (2006), etc. have confirmed BIM as a tool to be used while developing healthcare facilities. Cooper (2008) reported that BIM can address the hospital’s changing infrastructure needs with focus on human issues by anticipating problems that need to be solved ahead of time.

In addition, while developing a proposal, the quality of the indoor environment should be considered. For example, while planning the Dell Children’s Hospital, in the US, interior light shelves were not permitted because they can act as a dust collector thus spoiling internal environmental quality (Cassidy, 2010). During an interview and a site visit to a recently completed healthcare project, it was observed that due to a lack of studies related to solar heat gain and thermal simulation of designs some offices were very cold even on sunny days and some offices needed to plug in heaters in winter despite having central heating. Also, the thermal comfort in such buildings is very poor despite modern specification of the building’s envelope. An appropriate study related to solar heat gains can help to save a significant amount of energy and improve thermal comfort. During the refurbishment of an ambulatory care centre in Canada, a concrete canopy was added to minimize the solar heat gained through south-facing double height transparent façade (Phillips, 2004). An effectively oriented (i.e. with consideration to sun-path) healthcare facility in Texas helped to maximise the utilization of daylight. It was reported that 80 per cent of the patients’ rooms and 35 per cent of the diagnosis and treatment rooms received natural daylight resulting in significant energy saving (Cassidy, 2010) and other health related benefits.

So, the refurbishment cycle is divided into four main phases: proposal, design, construction, and use. The measures for the Phase I and Phase II and summary of all the phases are presented below in tabular format (Tables 2-4). The tables are based on the “A Guide for Low Carbon Refurbishment” (Carbon Trust, 2008) and collected data from various sources such as interviews, web-based case studies, etc.
### Table 2: Phase I- ‘Proposal’ during refurbishment of healthcare facility

<table>
<thead>
<tr>
<th>Measures</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Compliance with progressively tightening building regulations</td>
<td>1. Involvement of stakeholders and carbon champion</td>
</tr>
<tr>
<td>2. Provision of Energy Performance certificate (EPC)</td>
<td>2. Low carbon refurbishment commitment and vision</td>
</tr>
<tr>
<td>3. Better comfort, satisfaction, and productivity</td>
<td>3. Establish the current carbon footprint of buildings</td>
</tr>
<tr>
<td>4. Reduction in operation cost</td>
<td>4. Develop low carbon outline brief</td>
</tr>
<tr>
<td>5. Recruiting and retaining staff</td>
<td>5. Pre-refurbishment and post-refurbishment assessment</td>
</tr>
<tr>
<td>6. Benefits of commitments to reducing carbon emission</td>
<td>6. Set carbon targets for the refurbishment</td>
</tr>
<tr>
<td>7. Simple, way-finding design</td>
<td>7. Budget for low carbon elements</td>
</tr>
<tr>
<td>8. Life-cycle assessment</td>
<td>8. Empower and choose an appropriate design team</td>
</tr>
</tbody>
</table>

### Table 3: Phase II- ‘Design’ during refurbishment of healthcare facility

<table>
<thead>
<tr>
<th>Measures</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Passive measures (day-lighting to reduce need for artificial light)</td>
<td>1. Keep the low carbon theme up front</td>
</tr>
<tr>
<td>2. Upgrading of building fabric (insulation, windows) to improve thermal performance</td>
<td>2. Develop an integrated low carbon design and whole life costing</td>
</tr>
<tr>
<td>3. Efficient heating, ventilation, and air conditioning (HVAC)</td>
<td>3. Allow flexibility in design</td>
</tr>
<tr>
<td>4. Low energy lamps and correct lighting levels</td>
<td>4. Encourage exploration of a wide range of low carbon options</td>
</tr>
<tr>
<td>5. Modern lighting equipments such as occupancy sensors</td>
<td>5. Use energy modeling data</td>
</tr>
<tr>
<td>6. Energy management system</td>
<td>6. Manage the budget and scope</td>
</tr>
<tr>
<td>7. On-site generation of energy for e.g. CHP or biomass boilers</td>
<td>7. Approved integrated design</td>
</tr>
<tr>
<td>Phase III Construction</td>
<td>Phase IV Use</td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1. Selection of appropriate contractor and subcontractor</td>
<td>1. To make sure operator and occupants understand the building</td>
</tr>
<tr>
<td>2. Ensure effective project management</td>
<td>2. To conduct post-occupancy evaluation</td>
</tr>
<tr>
<td>3. Get buy-in from site works</td>
<td>3. To make changes depending on energy use and comfort conditions</td>
</tr>
<tr>
<td>4. Monitor site progress against objectives</td>
<td>4. Make the most of the low carbon building</td>
</tr>
<tr>
<td>5. Energy monitoring</td>
<td>5. Meet building regulations</td>
</tr>
<tr>
<td>6. Satisfaction of aim, objectives, and goals</td>
<td>6. Improved energy performance after refurbishment</td>
</tr>
</tbody>
</table>

### THE PROPOSED CONCEPTUAL FRAMEWORK

Refurbishment projects often involve extensions or part demolition along with full or part refurbishment. It is thus extremely difficult to define boundaries as well as exact scope of work and definition of refurbishment project. In this research refurbishment has been defined as “any existing buildings more than three years old considered for part or full renovation, extension, and/or retrofit” with specific focus on buildings constructed from 1980s onwards. The reason being that review of literature and interviews revealed that buildings especially constructed in 1970s and 1980s are not easy to maintain, poor in performance as well as aesthetics. However, considering the complexity of healthcare facilities, round the clock running and to be operational during refurbishment, it is not appropriate to consider refurbishment with a very narrow focus (energy) and limited scope. Hence, refurbishment is considered from energy as a key point of view, along with other possible construction considerations.

#### 2.1. Description of framework

Investigation revealed that refurbishment is time consuming and a lengthy process, but can be very effective if executed in well-planned phases (as indicated in Section 1.3 and with the help of Tables 2-4). Considering changing regulations and development in medical equipment, a refurbishment project executed over a five year span will be both ineffective and expensive. So, the refurbishment process is classified into three major categories: pre refurbishment, refurbishment, and post refurbishment. The resulting classifications and support systems for each phase are shown in Figure 1.
The focus of the framework is on the development of refurbishment proposal, so some construction related activities such as tendering, bidding, etc. are not considered, but are also important and related.

Also, the suggested process (support system) is in a hypothetical order because of the highly collaborative nature of the refurbishment process. The support system can be employed simultaneously by several team members during the process. The ‘purpose’ mentioned in the framework (see Figure 1) acts as the interface between ‘phases’ and the ‘support system’; it will help to promote a well-integrated process to ensure successful refurbishment of existing facilities.

![Figure 1: Conceptual framework for refurbishment](image)

The framework is divided into three columns: *phases*, *purpose*, and *tools/process*. The left column helps to define the phase and stage of a project, the middle column (purpose) denotes the purpose of the phase and the right column
(tools/process) shows objectives of that specific stage and purpose. To understand the relation between three columns, refer to Figure 1. For example, during ‘Phase II’ of a project, and at stage 2 ‘options for energy and carbon emission’ the ‘purpose’ of that stage will be to ‘compare’ the project status and ‘develop’ the proposal with the help of ‘tools/process’ such as energy and carbon related targets which is a ‘support system’ for entire project.

The arrows indicated between ‘phases’ and ‘processes’ show the relation between them and tools to be employed during those phases. For example, the arrow between business case and pre-project survey indicates a need to conduct a facility survey before developing a business case for the facility. Moreover, the survey will provide various inputs for the business case to make it more exclusive which will ensure the success of refurbishment projects. Also, in the future, the connections between the phases and the process will be developed further. Moreover, a brief list of activities and tools is presented which will be developed further during the process to make it more exhaustive. With the help of Table 1 and the objectives presented in Section 1.3, aim, objectives, goals can be developed to be used as part of the framework.

Phase I: a pre-construction primary design phase, where most of the decisions related to end product will be taken. Table 2 and this phase will serve as guidance during the development of the refurbishment proposal. In this phase, various opportunities are provided to consider different options which can have an impact on the overall life-cycle of the facility. The design team members are key actors in this phase.

Phase II: an early construction phase where most of the decisions taken in the previous stage will be developed further and implemented with the help of Table 3. During this phase, there will be some physical data inputs such as solar heat gains based on the actual site location, from a site team, to be used for further development of the project. During this phase most of the activities will happen on site with less work in the design studio however, there will be a very limited scope to consider different energy saving and construction features in this phase. At this stage of the project, most of the activities will be taken over by the construction team.

Phase III: a late construction phase before handing over the facility to the client/users. Most of the proposed ideas are implemented during this phase. There are very few possibilities to make any changes at this point; any changes during this phase will lead to a delay in the delivery of the project. During this phase most of the activities will be led by the construction team, leaving little scope for the design team to take any decisions.
Phase IV: a post-construction phase that leads the project to completion. Also, this phase will help to justify the refurbishment proposal and can assess verify the strengths and weaknesses of the proposal. Moreover, the phase will help to provide some learning to be used on refurbishment proposals in the future. During this phase the facility manager is the leader and can corroborate design proposal (Phase I). During this stage the key step will be to convey design considerations related to energy saving, etc. to the facility manager. All other points mentioned previously in Section 1 such as project aim, objectives, and goals will be accomplished with the help of the framework to achieve successful refurbishment.

Table 4 will help and guide Phase III and Phase IV to develop objectives for both the phases. Information provided in Section 1 will help during different stages and phases of the framework such as business case, master planning, target setting and energy monitoring to be accomplished.

**DISCUSSION AND CONCLUSIONS**

It is concluded that research in the area of refurbishment of existing hospitals has been neglected and there is a need to develop approaches for the existing healthcare facilities to achieve overall sustainability. The major objective of this study is to propose a framework for refurbishment including other factors such as energy. Significant energy savings are easily achievable with more sophisticated planning and mechanical systems by reducing air volumes and using appropriate energy features. In this research, various ideas and strategies from various projects are compiled together to propose a competent refurbishment framework to be used for existing hospital refurbishment.

A brief overview of a proposed framework and its key components has been presented in this paper. This paper suggests that during refurbishment there are various opportunities to save energy and to provide improved indoor environmental quality. As the paper is an outcome of ongoing research, the framework will be developed further. In the later phase research will be focused on the integration of BIM and simulation tools related to energy and solar studies. The future research and development of the framework will look at interfacing various tools and methods during refurbishment to save energy throughout the life-cycle of the facility such as interface between BIM, energy simulation tool (e.g. IES_VE, Ecotect, etc.) and government targets. The main objective of the framework is to save energy without compromising patient comfort. Also, this should be one of the key objectives for every healthcare project. The proposed framework is for architects to understand the types of tools, process, and drivers related to refurbishment. Also, facility managers and client can use the framework to keep control over a process, such as by deciding driving factors, etc.
REFERENCES


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