AN INTEGRATED DECISION SUPPORT MODEL
FOR THE SUSTAINABLE REFURBSIHMENT OF HOSPITALS
AND HEALTHCARE FACILITIES:
DEVELOPING A PROTOTYPE

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CERTIFICATE OF ORIGINALITY

This is to certify that I am solely responsible for the work, which has been submitted within this thesis. Apart from where identified, by means of referencing, I confirm that the contents of the thesis are original and my own. I confirm also, that no part of the thesis has been submitted to any other institution or body in consideration for any other degree or qualification.

………………………………………………………… (Signed)

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ACRONYMS AND ABBREVIATIONS

ADB	Activity Data Base
AEC	Architecture Engineering Construction
AEDET	Achieving Excellence Design Evaluation Toolkit
A&E	Accident and Emergency
ASPECT	A Staff and Patient Environment Calibration Tool
BEMS	Building Energy Management System
BIM	Building Information Modelling
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BRITA	Bringing Retrofit Innovation to the Application
BS	British Standard
CABE	Commission for Architecture and the Built Environment
CAD	Computer Aided Drawing
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
CDM	Construction Design and Management
CEL	Chief Executive Letter
CHP	Combined Heat and Power
CIM	Capital Investment Manual
CO2	Carbon dioxide
CRC	Carbon Reduction Commitment
DEFRA	Department for Environment, Food and Rural Affairs
DM	Decision Maker
DfT	Department for Transport
DoE	Department of Energy
DoH	Department of Health
EBD	Evidence-based Design
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union

FBC	Full Business Case
GBC	Green Building Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GP	General Practitioner
GRI	Global Reporting Initiative
GUI	Graphical User Interface
HaCIRIC	Health and Care Infrastructure Research and Innovation Centre
HAI-SCRIBE	Healthcare Associated Infection System for Controlling Risk in the Built Environment
HBN	Health Building Notes
HEAT	Health improvement, Efficiency, Access to services, Treatment
HFS	Health Facilities Scotland
HTM	Health Technical Memorandum
HVAC	Heating Ventilation Air Conditioning
IA	Initial Agreement
IAQ	Indoor Air Quality
IDP	Integrated Design Process
IEQ	Indoor Environmental Quality
ISO	International Standards Organisation
JV	Joint Venture
LCA	Life–Cycle Assessment
LCC	Life-Cycle Cost
LDP	Local Delivery Plan
LEED	Leadership in Energy and Environmental Design
LIFT	Local Improvement Finance Trust
LZC	Low and Zero Carbon
MADM	Multi-Attribute Decision Making
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision Making
MODM	Multi-Objective Decision Making
NAO	National Audit Office
NEAT	NHS Environmental and Assessment Test
NHS	National Health Service
NIHR	National Institute for Health Research

NSS	National Services Scotland
OBC	Outline Business Case
OECD	Organisation for Economic Co-operation and Development
OGC	Office of Government Commerce
OJEU	Official Journal of the European Union
PAMS	Property Asset Management Strategy
PCT	Primary Care Trust
PFI	Private Finance Initiative
POE	Post-Occupancy Evaluation
PPP	Public Private Partnership
PSCP	Principal Supply Chain Partner
RIBA	Royal Institute of British Architects
SAP	Standard Assessment Procedure
SBEM	Simplified Building Energy Model
SCIM	Scottish Capital Investment Manual
SDAP	Sustainable Development Action Plan
SDU	Sustainable Development Unit
SFT	Scottish Futures Trust
SG	Scottish Government
SGHD	Scottish Government Health Directorate
SHA	Strategic Health Authority
SHBN	Scottish Health Building Note
SHTM	Scottish Health Technical Memorandum
SPeAR	Sustainable Project Appraisal Routine
SOGE	Sustainable Operations of the Governments Estate
USGBC	United States Green Building Council
VFM	Value for Money
VOC	Volatile Organic Compounds
WBCSD	World Business Council for Sustainable Development
WE	Weighted Evaluation
WHO	World Health Organisation
WLC	Whole Life Cost

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For my family, this work is dedicated to the memory of my Dad, and to the untiring support from my Mum. Your belief and support have been more valuable than you know. Thank you for being there for me. The rest of the cheerleaders are also thanked…Gerry, Bill, and other good people, who know who you are.

ABSTRACT

The National Health Service (NHS) is recognised as the largest public sector institution in Europe. This presents significant challenges in regards to operation and maintenance of the diverse built estate, and the ever-evolving clinical models of care. The economic downturn, and strict policy of austerity in the UK, presents limitations and challenges in capital investment. The majority of healthcare facilities which will be used throughout the 21st century, have already been built. This demands that solutions be found in the areas of asset maintenance and refurbishment. These challenges are complicated further, by the institutional and statutory requirements of the NHS to meet demanding sustainability targets. This in turn, is underpinned by exacting assessment methodologies and rating systems, and critically, an institutional 'duty' to pursue and evidence that 'Value for Money' has been achieved as far as reasonably practicable. The existing estate management tools were assessed by a process of triangulation, and the relevant decision-makers and stakeholders from both the NHS and the Design Teams and Constructors were identified. The original contribution demonstrates the development of a novel decision support prototype which facilitates and improves the current decision making process. The prototype allows the integrated team to consider, evaluate, and agree, best-fit options in a measured, recordable, and replicable manner. Key to this process, is the ability to compare and rank often competing criteria, and to test the non-financial, and financial preferences by means of sensitivity analysis techniques. The research and the developed working prototype, were then tested and validated against an expert panel, on a broad scope of issues, ranging from Graphical User Interface aesthetics and usability, to functionality and applicability to the current standard business case process. The results of the testing and validation excercises were overwhelmingly positive.

Keywords: Hospitals. Refurbishment. Sustainability. Decision-making. MCDM. Capital Investment. NHS

"You see, flying takes
three things: hard work,
perseverance and…
hard work."

Rocky (voiced by Mel Gibson) in *Chicken Run*

CHAPTER ONE INTRODUCTION

1.1 Introduction

The National Health Service (NHS) is the largest public sector organisation in Europe (NHS SDU 2009) Correspondingly; this establishes the NHS as requiring the largest European built asset property portfolio. The issue of scale is expanded still further, in identifying an estimated 1.3 million personnel *directly* employed by the service (NHS Jobs 2011) Unique characteristics of healthcare as a discipline, and the associated minimum requirements demanded for the clinical aspect of healthcare service provision, place additional external pressures to the operational efficacy of the service. This includes areas such as changing demographics of the service users, evolving modern diseases, advances in pharmaceutical treatments, and the continual development of new medical technologies. These examples (being representative of a far wider and more complex set of challenges), exist against a backdrop of an ageing and fragmented built estate, and the 'duty' of NHS estates professionals, and design team professionals, to maintain both the physical assets, and the service itself, whilst demonstrating that best Value for Money has been pursued. To achieve this, a measured and systemic approach is required that captures the social, environmental, and economic needs of the service and its built assets. Such a system is required to integrate the key professional stakeholders in the decision-making process, in respect of the design, specification, and operation of the healthcare facility.

1.2 Context of the Research

The economic challenges faced by the NHS in the UK are arguably the toughest since the formation of the service in 1948. There exists an almost paradoxical situation, whereby the institution is required to adapt to and accommodate an expanding population, which is also becoming a longer living, and ageing population. A direct consequence of this, is that patients are more frequently presenting for the treatment of co-morbidities and multiple medical conditions. It is emphasised from the outset, that as publicly funded institution, the NHS is resourced through taxpayers money, and as such is highly sensitive to the wider economic situation on a national level. Therefore, in direct opposition to the aforementioned challenges relating to the expansion of service needs, 'efficiency drives' dictated by government policy have demanded that the NHS (in England) operate with a year on year funding reduction of 4%, which equates into a real cash figure of between 15 and 20 billion pounds (BBC News Online 2010) NHS Scotland are faced with similar challenges, and has been identified as facing an 'unprecedented squeeze' in its budgets and finances (Scotsman Online 2010)

The NHS is challenged further still, by the requirements of recent (and constantly evolving) legislation and regulations, especially in the context of sustainable development. The social, environmental, and economic dimensions of the sustainability model, are well placed to capture the potential solutions for the NHS challenges within a single model, and yet, by the nature of the legislation and regulation referred to above, an ambitious and potentially dogmatic approach has set targets and standards which, especially in an economic and political environment of reductions in funding, may be viewed in some respects as compounding the challenges as opposed to alleviating them. From a high level perspective, this is most clearly evidenced by the passing of legislation, which, for the context of the research, is driven by the *Climate Change (Scotland) Act 2009* (The Scottish Government Online) which focuses heavily, and in detail, on the reduction of greenhouse gas (GHG) emissions (notably, carbon). In the context of a built estate consisting of solely new-build facilities, an 80% reduction in GHG emissions by 2050 (from a 1990 baseline) is highly challenging. However, as will be discussed, the majority of the built estate of which the NHS comprises, is not new-build, but is existing and of varying ages and conditions. This exacerbates the challenge. This is especially true, when the service provision aspect is featured into the problem. Expansion of the NHS (driven largely, by the demographic etc. challenges described earlier) has actually increased the overall carbon emissions of the institution by 40%, measured again, against the 1990 baseline (NHS SDU 2009) This presents an almost 'Canute' type challenge.

From a more detailed perspective, and in relation to the vast number of individual built assets and healthcare facilities across the country; design and planning specific regulations and requirements also present their own set of challenges. A key example of this can be seen by considering the requirements for new-build and refurbishment works (within certain parameters) to attain a *Building Research Establishment Environmental Assessment Method* (BRE. BREEAM for Healthcare 2009) certification, as a requirement of the business case and funding release process. Again; the differentiation between new-build facilities, and the far more prevalent refurbishment (including major maintenance) projects on the existing estate, is critical. The significance of this last point, to both the challenge faced by the NHS, and to the main aims and objectives of the research is absolutely key. As observed by Sheth (2008) and referred to previously, the majority of the NHS built estate which will be uitlised throughout the 21st century, has already been built. This places the activity of refurbishment at the forefront of the search for affordable, efficient, and sustainable solutions, which also satisfy the high level and facility-focused regulatory targets and legislative requirements.

In real and practical terms therefore, a 'bottom up' approach is unavoidable, in the sense that the collective metrics required to achieve the high level results discussed, will be measured from the combined performance outcomes of individual hospitals and healthcare facilities. This in turn, identifies the early decision-making and business case processes as being the optimum intervention points for making integrated and value for money focused decisions. Given the complexity of the hospital as an asset, and weighed against the well-documented and recognised challenges faced in undertaking a refurbishment project, a measured, weighted, and ranked decision making process is critical. The nature of the BREEAM assessment (for example) does not facilitate the assessment of the hospital as a unique asset. Such a 'one size fits all' methodology is therefore ill suited to application on a facility that very possibly has a fixed form, orientation, and function. Similarly; a high proportion of the healthcare estate is itself aged, and as such may not be physically able to adapt and accommodate new systems, elements, or components, without a potentially self-defeating level of financial investment.

1.3 The Research Problem

The main purpose of the research was to understand the issues faced with the refurbishment of hospitals and healthcare facilities in the context of sustainability driven challenges. It was therefore essential, to set aims and objectives within the research design that would ensure that enough data and information was collected to allow inferences to be made, and to direct the ensuing paths of enquiry. A key outcome was identified as being the design and construction of an integrated decision-making prototype/model. The model required to combine the high level requirements of the NHS at institutional 'asset management' level, with the facility level business case challenges in selecting best-fit options and demonstrating that Value for Money had been pursued *specific to the facility being considered*. The differing perceptions of the NHS and the design teams, on the ranking of key criteria was recognised as presenting a potential barrier to consensus and therefore optimum selection of a final option selection. Therefore, the provision of a professionally inclusive, and integrated decision support platform was identified as being critical. This criticality was double edged, in the sense that a formalised, measured, and systemic mechanism was required to eliminate professional bias or overly heuristic influences; but also required, was the more non-tangible goal of integrating and engaging the decision-makers themselves, in a logical, yet simplified manner.

1.4 Aims and Objectives

Aim

To develop an integrated decision support model for the sustainable refurbishment of hospitals and healthcare facilities, and to test the model through application of a working prototype.

Objectives

The objectives required to satisfy the main aim of the research are discussed in order of listing, throughout the thesis. These are:

1. Review the integrated nature of the hospital in the context of sustainability driven refurbishment requirements
2. Explore the range of related sustainability assessment methodologies and model types and consider these in the context of the NHS
3. Investigate Environmental Management Systems and consider these in the context of the NHS
4. Examine the phenomenon of decision-making as an activity, and assess its application in the context of the business case process
5. Understand and present the capital investment and asset management processes, applicable to the NHS, and to describe their relevance and position within the refurbishment process, and the decision making function
6. Design a conceptual decision support model with the help of secondary data collection
7. Design a decision support framework with the help of both secondary and primary data collection excercises
8. Develop a functioning software based, decision support prototype, built from the conceptual and framework design processes
9. Test and validate the completed decision support prototype with industry experts and potential model user groups.

The objectives given above, mirror the design and format of the thesis itself. These should be read in conjunction with the *Research Methodology* chapter for context in regards to the wider aims and philosophical assumptions.

1.5 The Research Questions

A set of research questions was developed throughout the research. These have been developed from a number of sources, and this is explained in greater detail within the *Research Methodology* chapter. The questions have developed into 2 main research questions, each of which is explored through a series of sub-questions (A to F). These are presented below:

Question 1

Is there a requirement for a decision support model for undertaking sustainable refurbishment of hospital and healthcare buildings?

A. Do current tools and processes identify areas of priority in identifying key decision making criteria?
B. Do current tools and processes offer a best option, or alternative for the project, based on 'project specific' criteria?
C. Is there a formalised management/facilitation process, that ensures that a rigorous and demonstrable decision making process has been undertaken? (within the mandatory institutional requirement to demonstrate Value for Money)

Question 2

Are Multi Criteria Decision Making techniques applicable to the undertaking of sustainable refurbishment of hospitals and healthcare facilities?

D. What is the level of knowledge and application of MCDM techniques in regards to the current Business Case process?
E. Are MCDM techniques compatible with the existing systems and processes used within the current Business Case process?
F. Can the use of MCDM modeling techniques, demonstrate that Value for Money has been achieved as far as reasonably practicable, specific to the project in question?

1.6 Significance of the Research

The research is geared specifically, to explore an area of the current business case process that is both highly challenging, and highly topical. The current requirements from the NHS at asset level, in regards to rationalization and prioritisation of essential backlog maintenance issues, take center stage in many respects, when attempting to manage a constrained refurbishment budget. Demonstrating that best Value for Money has been pursued on capital expenditure, is a constant requirement for both the NHS as the Client, and the design team and contractors responsible for the refurbishment contract and works. Integration of stakeholder groups in the decision making process, and facilitating consensus on what actually constitutes Value for Money is therefore of key significance.

1.7 Scope of the Research

It was considered essential to explore the subject matter from an initially wide perspective that encompassed the NHS in both England and Scotland. Fundamentally, the issues and challenges are exactly the same in regards to the issues of sustainability, refurbishment, and the hospital itself. However; once the research progressed into the *Contextual Background* chapter, the differences between the governance and procedural management of the English and Scottish systems became more apparent. This directed the focus of the research to consider the asset management and business case processes associated with NHS Scotland. In the context of researching the built asset itself, the over-arching objectives of the report, were designed to consider all healthcare associated facilities of which, the hospital is only one type. For the purposes of the model development however, the standard acute hospital has been used as the exemplar facility type throughout the report (unless stated otherwise) To provide the required amount of background, documentation, and detail therefore, a specific hospital facility has been identified within a selected Health Board for use within the demonstration case study.

1.8 Research Contribution

The research contribution cannot be viewed in isolation, due to the multi-dimensional nature of the process. The gap in terms of the current process and systems is in the 'disconnection' between the outputs of the *EstatesManager System* (and the associated ranked, prioritised, and potentially costed backlog maintenance actions), and the carrying forward of the same actions into the physical refurbishment process via the standard Capital Investment Business Case. The secondary and primary data collection exercises support this statement, in identifying that no structured or formalised methodology is currently employed to consider, measure, and specify, the 'best fit' option, which satisfies not only sustainability related requirements, but demonstrates that Value for Money has been pursued. The original contribution, in this context, is focused on the exploration and delivery of a facilitated decision making process, which engages the NHS/PSCP actors by a process which mines the heuristic expertise of the 'collective group', and allows this to be quantified and mathematically weighted to provide a range of 'best fit' options, supported and validated throughout, by the regulatory, legislative, and institutional requirements *specific to the facility in question*.

1.9 Overview of the Thesis

Chapter 1

This chapter describes the research area in summary terms, thus providing the context for the main body chapters of the thesis. The research problem is framed against the key aims and objectives. The significance and scope of the research are described, and the final section describes the original contribution.

Chapter 2

A detailed literature review is undertaken and presented to provide the detailed context for the research. The key dimensions of the research are described in their component parts before being reviewed as an integrated issue. Throughout the chapter, the research questions are discussed and formed, sign-posting the direction of travel for the research process and model development.

Chapter 3

The contextual background is presented as a stand-alone chapter. The specific nature of the management systems and processes discussed within the chapter are not deemed relevant to be reviewed as part of the literature, as reference is made throughout chapter 2 where necessary. Nevertheless, the systems discussed are critical in providing a framework or platform for the ongoing research and model development.

Chapter 4

The research methodology and the research methods framed within it, are discussed and presented in this chapter. A wide approach is taken initially, discussing and exploring the philosophical assumptions that exist, and those, which have been identified as pertinent to the research. The research methods are then described in detail, specific to the research project and the identified sample frame.

Chapter 5

This chapter presents the key results taken from the data collection exercise. These are analysed and discussed in the context of the developing model. Simple descriptive statistical presentation techniques have been employed, and where necessary, key findings have been broken down for more detailed analysis and inference. The key results within this chapter, compliment the complete set of results contained within the appendices.

Chapter 6

The development of the model/prototype is discussed in great detail within this chapter. Each phase is described in chronological order of development, from the conceptual, through the framework construction, to the development of the software based platform itself. The methodology and calculations associated with each phase of the development is described and presented.

Chapter 7

The software based model/prototype, is tested and validated by a group of selected industry experts and identified user groups. A case study example of a live project is used as the exemplar. Statistical results on the performance and utility aspects of the model and the graphical user interface have been collated and presented.

Chapter 8

The thesis, the research findings, the model development, and the testing and validation findings are discussed in terms of strengths, weaknesses, and limitations are discussed. The research objectives are discussed and identified within the thesis. Conclusions relating to the entire project provide a definite parameter to the research project, and informs a section on suggestions for future research and further model development.

References

A complete list of references are provided. These adhere to the Harvard referencing system.

Appendices

The appendices contain relevant reference documentation to support the main chapter bodies throughout the thesis. This includes copies of all questionnaire forms, and full sets of collected data. Abstracts for selected publications are placed in the appendix, as is a full copy of the illustrated prototype user guide.

CHAPTER TWO THE LITERATURE REVIEW

2.1 Introduction

The literature review will address seven main sections. The first three sections of *sustainability*, *refurbishmen*t, and the *hospital in context*, are presented as stand alone subject introductions and discussions. The fourth section titled, *hospital refurbishment and sustainability,* progresses the literature review in discussing section one to three in terms of integration*.* Sections five, six, and seven explore the discussion still further, and in the context of the research main aims and objectives, reviews *sustainability assessment models, environmental management systems,* and *decision making models*, respectively. This approach is indicative of the overall research methodology and the subject matter itself, in the sense that although complex and involved topics within their own right, an integrated approach is necessary to establish connections, dependencies, and the framing of the research questions.

2.2 Sustainability

2.2.1 Defining Sustainability

From the outset, identifying a single or focused definition of the term *sustainability* proves to be a challenging task. There may be a common and simplified perception that sustainability is related to mainly environmental issues such as ecology, which paradoxically, although correct, is also incorrect, or more accurately *incomplete*. A derivative of the root word 'sustain', the Oxford English Dictionary (2010 pp. 765) defines *sustainable* as:

"1) Able to be continued or sustained. 2) [of industry, development, or agriculture] avoiding using up natural resources."

This succinct definition is however, severely limited, and supports the common view of relating sustainability specifically to the natural world and its resources. In a letter to the *Ecological Society of America*, Gatto (1995) identified three distinct definitions of sustainability as being:

1. Sustained yield of resources
2. Sustained ecosystem
3. Sustained economic development

These multiple definitions are demonstrative of what Gibson referred to as an essentially…*"integrative concept"* (Gibson 2006) This aspect of integration is key to understanding that although sustainability has an extremely wide scope in definition, the definitions themselves are not necessarily incorrect or contradictory of each other, but inherently connected, or as described by Dahl (1996) in a state of balance and equilibrium. It may be easily construed that any intervention or upset to this balance may result in a condition of *unsustainability*; to either the factor affected (or indeed, through the concept of integration) have a knock on effect in another area. What Dahl also brings to the interpretation is the aspect of the 'temporal dimension'. This appreciation of a timeline is fundamental in knitting together all of the dimensions considered within the concept of sustainability. Energy, materials, wealth, and life itself have temporal limitations, and sustainability in its simplest form must, it would appear, follow a basic formula of 'balancing the books' in regard to such areas as maintenance versus depreciation, replacement versus degradation, or renewal versus loss.

2.2.2 Defining Sustainable Development

In defining sustainable development, framing the core issue of sustainability within a temporal focus is a cornerstone for interpretation. Using what is probably the most widely known and commonly understood definition of sustainable development, the importance of the principle of time can be clearly seen. The definition referred to stems from what is generally referred to as *The Brundtland Report* (Our Common Future 1987), which defined sustainable development as:

"…development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."

It is clearly communicated, that the implicit requirement for any developmental process or action taken in the *here and now,* must be evaluated against the possibility of detrimental impact or effect further down the timeline. This is demonstrated in simple arithmetic terms in the 2006 *Living Planet Report* (WWF), which calculated the (then) global 'ecological footprint' as exceeding the planets regenerative capability by about 25%. To clarify further, such an imbalance requires 15 months to produce the global resources that are being used in a year. There seems little doubt on the unsustainability of this situation.

This 'quantification' or measurement of sustainable development is the next logical step following definition and interpretation. The first point in measuring or monitoring sustainable development is the identification of what is actually to be measured, or the relevant metrics. At this very early stage, the importance of identifying of key criterion is emerging as a fundamental requirement to the research design. At its highest level, this is approached through modeling sustainability to identify its main component parts.

2.2.3 The Sustainability Model

There is more than one model that seeks to visualise sustainability (sustainable development) and its component parts. One of the most widely recognised is the tri-partite Venn diagram (Gibson 2006), which shows the three constituent parts of the sustainability model (and philosophy) and the integrated nature of their connections (Figure 2.2.3).

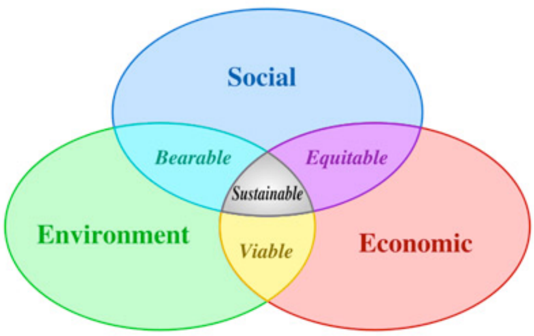


Fig 2.2.3: The integrated sustainability model (Gibson 2006)

Other models have been created and used across the disciplines, however, the model presented in Figure 2.2.3 seems by far, to be the most commonly encountered throughout the literature.

2.2.3.1 Social

The social aspect of sustainability is, as the name implies, concerned with the human or person centred aspect of the model. Although consideration of the human element may seem fairly obvious, there is nevertheless an irony in the fact that it is probably the least understood or focused upon aspect of the model. Lombardi (2001) identifies the emotional aspects of social sustainability as including security, satisfaction, safety, and general comfort, whereas the possibilities of positive input are presented by Parkin (2000) as skills, knowledge, motivation, and health. By the very nature of the social dimension, there is capacity to present a vast review of this within its own right, however, for the present stage of the review, the over-arching understanding described above is sufficient.

2.2.3.2 Environmental

The environmental dimension of the model is often used inter-changeably with the term sustainability itself. This is given some credence from the structure of the alternative 3 nested dependency model of sustainability shown in Figure 2.2.3.2 (Scott Cato 2009). This places the component parts of society, and economy, as fully enveloped factors of the environmental component respectively. Figure 2.2.3.2 should be considered against the earlier discussion in section 2.2.3, in that it demonstrates one of the alternative models that may be encountered in physically representing sustainability as an integrated whole.

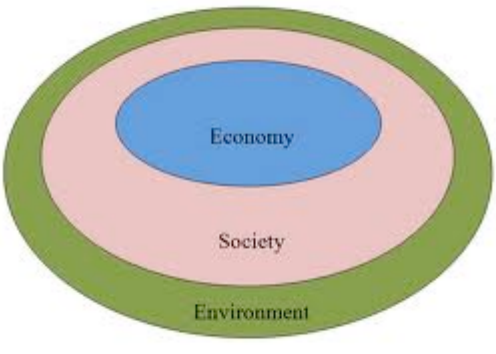


Figure 2.2.3.2: The 3 nested sustainability model (Scott Cato 2009)

However, despite the hierarchical logic suggested in Figure 2.2.3.2, it is proposed that this 'Russian doll' approach does not capture the integrative nature and philosophy of the more commonly recognised Venn diagram. There seems little doubt that one of the central principles of Sustainable Development (SD) is to live and plan within environmental limits, yet as recognised by the UK Sustainable Development Commission (Sustainable Development Commission. Online) SD demands a far broader requirement than concentrating on the environmental dimension as the key issue alone. In summary, although affected by social and economic factors, in broad terms the environmental aspect of the model addresses the more *natural* aspects of sustainability. Notably, examples of this will include material consumption, extraction of natural resources, impacts to land and water, and the effects of consumption and emission to the atmosphere. Again, this reiterates the developing criteria sets for the decision maker, later in the research process.

2.2.3.3 Economic

As the name implies, the economic component of the sustainability model is concerned with, and consequently measured, in largely financial terms. On a macro level, the economic component is a key driver by way of the international markets, which, by their nature, deal and trade in capital and resources. Elliot (2005) identified three broad categories of capital as consisting of *natural capital*, which is concerned with the actual earths resources, *human capital,* which measures the improvement potential of knowledge or skills, and *created capital*, which focuses on the manufactured goods which allow for the production of products and services. This 'capital' approach is inextricably linked to the actual quantity of resources available (whether natural or human) and economics, in this context, is succinctly defined by McEachern (2000) as being…

"…the study of the allocation of limited resources across unlimited wants."

The economic component has clear linkages to the other aspects of the sustainability model, perhaps most easily considered by effect on living standards and access to wealth. This could be true of both macro and micro economic issues. A prime example of the relationship between the economic component and the wider sustainability model is the area of Whole Life Analysis (WLA) or its financially focused sister Whole Life Costing (WLC). Kishk (2001) provides the definition that WLC is

"…the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset."

Although offered as a construction process based definition, this is easily interpreted in the context of both the macro and the micro economic approaches, and supports Elliots (2005) observation of economic sustainability as essentially a 'trade off' between current and future consumption. This concept of 'trade offs' will re-emerge throughout the thesis, as a keystone activity in shaping the decision-making process, and prototype design. This in itself, may be related to the similarly phrased Brundtland definition of sustainability as a whole, presented earlier and discussed in terms of balancing the books of the present against the future.

2.2.4 The Climate Change Argument

There is little doubt, that the issue of climate change has been an area of intense debate and argument in both scientific and political circles. This argument however, requires more detailed consideration. It is crucial to appreciate what the argument 'actually is' from the perspective of involved parties across the spectrum. These viewpoints are key to providing context on the drivers and/or barriers to the prioritisation, planning, and physical interventions to the healthcare estate, which are consequentially, key to the decision making process.

In economic terms, and for reasons associated with national revenue creation and tax collection, it seems that the main political parties in any country, are (perhaps?) susceptible to pressure from industrialists and investors in heavy industry to adopt a laissez faire approach to the issue of climate change, and to limit their interference in regard the status quo. At the other end of the spectrum, democratically elected governments are undoubtedly subject, through the electoral process, to the will of the people, and as such are forced to accept, or at least consider, the social zeitgeist. This apparent conflict of interest lies at the heart of the climate change argument. The argument in this context seems swayed towards the debate on whether human beings are actually responsible for the effects of a changing climate (whether wholly or partly), rather than the more fundamental and practical discussion on whether climate change as a phenomenon is *happening at all*. If, as proposed by many action groups and environmental bodies such as *Friends of the Earth, Greenpeace, Campaign Against Climate Change*, (as representative samples) the effects of climate change *are* indeed as a result of human activities; then it would be difficult to argue against the fact, that human beings as a species, have a moral and sane obligation to effect changes to the social and industrial behaviors in order to mitigate the negative effects. Those who hold the belief that climate change is a wholly natural phenomenon, (Again, from groups such as *Exxon-Funded Skeptics, Heartlands Institute,* or *The Tea Party*) independent of any human activity, take the view that applying strict regulations and economic responsibilities to a naturally occurring event, is an unacceptable, or even damaging approach, especially in economic terms. This does however, highlight that the debate is a continuum, and the examples cited are selected from the opposing ends of the scale. This distance of opinion is absolutely key, as the opposition of viewpoints illustrates what is perhaps, the most basic barrier to consensus, and a core consideration in conceptual terms, for the development of a functioning prototype, as will be demonstrated throughout the thesis.

Climate change as an issue, is a vast field in both scientific and political debate, and the very term itself is open to interpretation, or misinterpretation dependent on a wide range of opinions, beliefs, interests, or a range of other human variables. VijayavenkataRaman et al (2011) identify the phenomenon as…

"…a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or more)"

The existence of such statistical variations was presented by Mann (2012) in his much recognised (and itself much debated) 'hockey stick' model, which collected data from thermometers, tree rings, corals, ice cores, and historical records suggesting that over the measurement period of 1000 years, a rapid climb in temperatures has been occurring since the turn of the 20th century. The main identifiable reason for this rapid climb, has been attributed to the release into the atmosphere of *green house gases* (GHG). The Third Assessment Report on Climate Change (IPCC 2011) found that between the years of 1750 and 2000, carbon dioxide concentrations have increased by 31%, methane by 151%, and nitrous oxide by 17%. The Mann model however, is only one of many on the subject of atmospheric measurement. It would be remiss not to refer also, to the work of Charles Keeling (Scripps Institute) whose data measured the definitive increase of CO2 levels worldwide since the late 1950s (this being the start point of his measurements). Perhaps more significantly, the 'Keeling Curve' is a representation of the increase of CO2 resultant from the burning of fossil fuels, and the subsequent release of GHG into the atmosphere. This places the smoking gun, or at least part of it, at the feet of industrialised human beings. The description of these two key climate change models has been presented here in simplistic terms, and it is understood that all science and related modeling must have caveats. However, and on the face of things, the correlation between temperature rise, GHG concentrations, and the exponential increase in each models measurements and character, appear to create predictable and repeatable trends.

A simple approach to the divided views on the existence of climate change was presented within the *Report of the United Nations on Environment and Development* (1992) The report officially recognised the *precautionary principle.* The interpretation of the precautionary principle in the context of climate change and its effects, were presented as…

"Where there are threats of serious or irreversible damage to the environment, lack of scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation"

It is significant to note the direct reference to the 'cost effective', or economic aspect of the climate change debate. In real-world practical terms, the structure of the worlds economies and market instruments, pose what is perhaps the greatest barrier to a *global* consensus and subsequent action, not to mention public appetite and associated political will. The Report, *The Economics of Climate Change* (2006) progressed the debate, purely in terms of economics and finance. The report proposed that as…

"The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent response"

The basic ethos of the precautionary principle appears to be reiterated, although measured more quantitavely against the GDP figures of the worlds national economies. The report advises on the benefits of early action with strong political will, and recognised that although there will inevitably be costs; the potential costs of inaction are almost incomparable in scale and severity. It is thought provoking to reflect upon the timing of the Stern Report in comparison to the subsequent collapse of the Lehman Brothers Bank in 2008 (BBC News Online[1]) It is considered by many, that the collapse of Lehman Brothers was the beginning, and perhaps the catalyst, of the global economic crisis. The effects on world banking, and especially on the economic lending instruments have been powerful and rapid, and has had significant effects on the healthcare estate. Precisely the type of global participation and investment required in the recommendations of the Stern Report have, arguably, shifted on the priority list of countries and states whose immediate goal is to simply avoid national bankruptcy. In addition to this, both the precautionary principle and the findings of the Stern Review highlight *human specific* challenges, which have the capacity to prevent any real concerted action on a global scale. McGuire (2012) clarifies this observation, and discusses the nature of human ability to fully comprehend dangers, which he termed 'long emergencies'. He argues that human risk assessment evolved to react to near or present dangers, such as imminent invasion or attack, but the 'hard wiring' required to identify and strategically plan for threats of a more stealthy or long term nature, are absent on a species level. He continues, using as an example, the United States reaction following the attacks on Pearl Harbour in 1941 as a measure of large-scale group action in the face of imminent threat. In a six-month period following the attacks, the entire US economy reset itself with astonishing success, on an unprecedented scale to engage in a global conflict on multiple geographical fronts. To some therefore, it may seem surprising, that given the mounting scientific evidence and predictions of irreversible natural, social, and economic change (for the worse) on a global climatic scale; the social and political will (despite the global economic challenges) remains at best 'fragmented', and at worst 'indifferent'.

2.2.5 Climate Change and the Built Environment

Mirroring the climate change argument itself, the relationships and subsequent effects of changing weather patterns and temperature fluctuations in regards to the built environment, are inevitably an issue of *scale*. On the macro scale, societal infrastructure is placed in an increasingly vulnerable position due (in part) to the high population densities of the modern worlds cities. In the foreword to the book *Resilient Cities* (2011), Zimmerman presents the stark projection that the current city dwelling populations of the planet (whom are measured at almost half), is set to rise by 2050 to a statistical projection of 70%. Given that the majority of these figures refer to the rapidly expanding 'urban poor' population, especially in developing countries, it follows that those most affected by extreme weather or climate related events (again, in regards to scale), are likely to be those least able, geographically and economically, to deal with or recover from them. Extreme weather events are by no means restricted to the developing world however, as the 2012 Hurricane Sandy has demonstrated in New York (BBC News Online[2]) Infrastructure was paralysed, and tens of thousands of city residents were placed in a vulnerable housing situation. It should be borne in mind that this particular 'event' was fully expected and preparatory procedures were put in place on a mass scale, and yet the effects were still devastating. Compare this also to Hurricane Katrina; again, a devastating major weather event affecting one of the most developed and affluent countries on the planet. Focusing still, on the macro scale, extreme weather events have been commonly expected on practically an annual basis in many parts of the world, although the increased urban density and expanding population have the exponential capacity to affect more people and the infrastructure supporting them. A recent example, close to the time of writing, is the devastating 'Typhoon Bhopa' in the Philippines island of Midanao (BBC News Online[3]), which is projected to have destroyed up to 80% of the agricultural capacity, with an economic cost of circa $98m. On the other end of the spectrum (or the micro scale) the observer can see immediately, the level of destruction caused to individual properties and public buildings. In human terms, disruption or contamination to vital infrastructure services, such as the water supply, or transport networks, introduces the potential to promote the spread of infectious diseases or food shortages, respectively. Both of these examples ultimately place pressure on the infrastructure 'cornerstone' of *healthcare provision.* It may be argued that damaged or destroyed social infrastructure (in the form of built assets) are capable of contingency planning, but the hospital, and the healthcare function are perhaps the last, and most critical, line of defence.

Climate change effects are not however, restricted to such extremes as *catastrophe scale* events. As discussed in the Mann (2012) *hockey stick* model, one of the most noticeable effects of a changing climate, is the measured and recorded rise in global temperatures. Short et al (2012) provide one of the more explicit examples of temperature related effects in discussing the 15,000 "excess" deaths from the effects of a heatwave in Northern France in 2003. In the summer of 2006, the increase in heatwave related deaths in the UK was measured as adding an increase to the baseline mortality rate of 4%. It is emphasized here, that these deaths are not the result of a geographically targeted event, but measured on a national scale. Aside from the obvious observation that the death rate spikes dramatically, potentially from the effects of changes in the climate; as with the 'last line of defence' analogy given above in relation to large scale events, it is the existing healthcare infrastructure which is the ultimate institutional body on the front line of the society's situation management. The Report *Measuring Progress: Preparing for climate change through UKCIP* (2005) identified the major predicted effects that climate change may have, specifically related to the built environment. As with many other aspects of this issue, these must also be viewed in the context of scale, although the primary areas of potential danger are recognised as thermal discomfort in buildings (which, if related to the previous example, affect the practical requirements for an increased demand in summer cooling), storm damage and flood damage, alongside the regional shortages of water supply. These examples are far from exhaustive, and it is impractical to identify and address a single specific occurrence or effect. The nature of the built environment, the infrastructure supporting it, and the behaviour and demographic patterns of human beings, demand that an integrated approach be taken, and as will be demonstrated within the model development chapter, a system of 'scaling down' key criteria, and integrating the relevant actors, are essential in terms of developing a management tool.

2.2.6 Linking Climate Change to the Sustainability Model

Climate change and sustainability are both issues relating to environmental concerns. The much-recognised sustainability Venn diagram shows 'environment' to be only one dimension of a triple dimensional model, which also incorporates 'social' and 'economic' aspects. The environment in respect of climate change may be perceived as the complete atmospheric system in which humans reside. Sustainability by its very nature, is targeted strongly towards the reduction and/or replacement in use of the earths natural resources and fossil fuels. This applies to both finite resources such as oil and coal, but also replaceable resources such as timber or (arguably) water. It could be debated that given these 'on the earth' and 'around the earth' distinctions, that sustainability and climate change are in fact two completely separated paradigms.

However, this separation is challenged and it is suggested that in considering the potential adaptation requirements of the urban condition, then it is not only desirable, but essential to consider climate change and sustainability as two interlinking approaches. Figure 2.2.6 models this integration and illustrates the cyclic and connected nature of the main activities and problem areas.

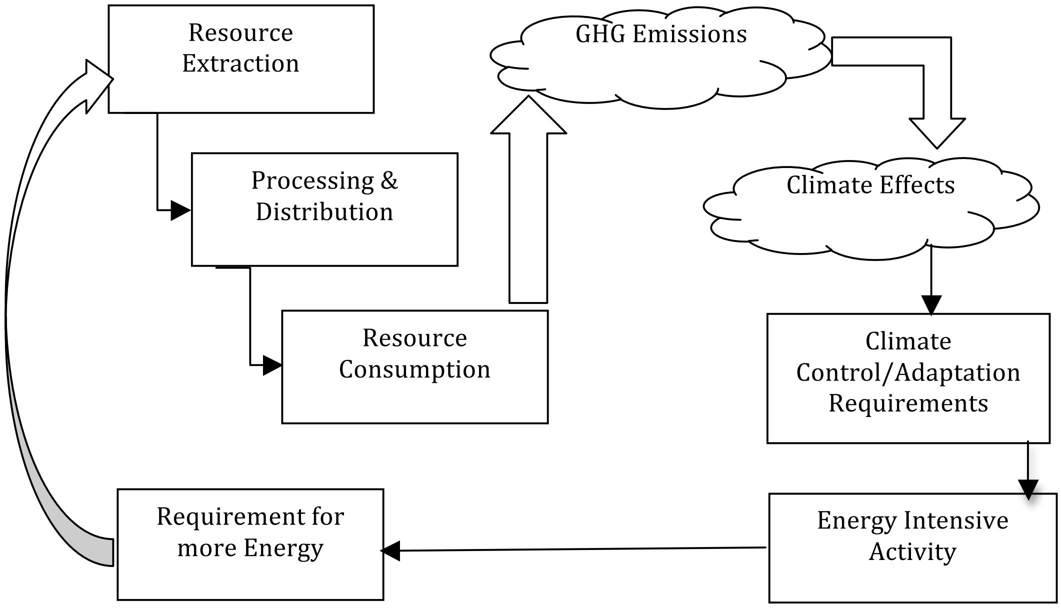


Figure 2.2.6. The climate change/sustainability link.

The model in Figure 2.2.6 is simplistic in its representation of the closed loop process inter-linking sustainability with climate change, yet it provides immediate opportunities to, firstly; identify the main interface points between sustainability and climate change issues, and secondly; to break the loop into distinct dimensions. This allows the observer the opportunity to identify optimal intervention points, designed to break or minimize the effects *and* impacts associated with each issue. As will be discussed within the Contextual Background, and the Development the Prototype chapters, the identification of the optimal intervention point is of great importance to the implementation of a physical management solution. Therefore, in addition to understanding adaptation in terms of scale, as previously discussed, adaptation *as an approach*, must also sit astride and incorporate both sustainability and climate change as an integrated process or phenomenon.

2.2.7 The Focus on Carbon Emissions

Notwithstanding the wider concerns on emissions of all GHG, the issue of Carbon Emissions, and consequently Carbon Reduction has, in many ways, taken centre stage in the sustainability debate. This may be considered in large part, as a result of the focus for legislative and regulatory drivers. Within the UK, the intensity of scrutiny demanded in this area has been increased with the introduction and passing of the *Climate Change Act 2008*

(Climate Change Act. 2008). Key provisions of the Act require a legal obligation to adhere to:

"A legally binding target of at least an 80 percent cut in greenhouse gas emissions by 2050, to be achieved through action in the UK and abroad. Also a reduction in emissions of at least 34 percent by 2020. Both these targets are against a 1990 baseline"

Scotland has it's own *Climate Change (Scotland) Act 2009* which, although mirroring the 80% reduction target by 2050, requires a more stringent 42% reduction by the interim date of 2020 (in addition to the requirement for achieving year on year reduction targets) (The Scottish Government 2011) In the early phases of the criteria selection process, Chapter 6 will demonstrate the importance of understanding the high level drivers in regards to the sustainability question. It will be clearly shown, that the reductionist method used for the selection process, is firmly grounded in the legislative and institutional requirements.

Although 'The Act' touches on all parts of industry and every sector (notably through such requirements as the *Carbon Reduction Commitment Energy Efficiency Scheme*, (Department for Energy and Climate Change 2010) which requires qualifying organizations to measure, report, buy, and even trade in carbon as a commodity), and with the appearance of sector specific bodies and organizations such as *The Carbon Trust* (online 2011), and the *Edinburgh Centre for Carbon Management* (Online 2011), Carbon and it's inextricably linked 'partner' of *energy consumption*, have become key factors, and perhaps even drivers, to the wider sustainability agenda.

2.2.8 Measuring Sustainability

The aspiration of the Brundtland definition of sustainability discussed earlier is well rounded in its simplicity and ability to encourage a greater element of common understanding. This could be expanded to perhaps include common purpose, and yet, the date of the conference report itself (1987) is significant in that the sustainability question has evolved into a different, more complicated discourse than it perhaps was a quarter of a century ago from the time of writing.

The concept of sustainability is extremely broad in its inclusion, and as highlighted previously, must address issues such as material consumption, fossil fuel depletion, water consumption, social well-being, and economic equitability. As an example of this, and in relation specifically to the built environment, UK Government reports (HM Government 2008) have identified that up to 50% of water consumption, 33% of landfill waste, and an overall 25% of all raw material usage are attributable to the built environment within the UK alone. Section 2.2.5 discussed the built environment in the context of the effects of climate change. It has been shown earlier also, that climate change and sustainability are inextricably linked (Figure 2.2.6), although this section demonstrates the steering of the review back to the built environment.

Although the measurement and assessment of sustainability will be reviewed in detail later within the literature review, it is instructive at this stage to signpost the specific relationships between sustainability, the built environment, and the measurement and management requirements.

2.3 Refurbishment

2.3.1 Defining Refurbishment

In the most basic of terms, a construction project is a well-defined process with fairly well established participants and methodologies throughout. A fair definition of the nature of a project is proposed by Kerzner (2001) in defining an undertaking of a temporary nature with a clear beginning and end point, and crucially, with a specific objective. This is echoed within the Project Management institutes (PMBOK 1996) definition of:

"…a temporary endeavour undertaken to create a unique product or service. Temporary means that every project has a definite end. Unique means that

the product or service is different in some distinguishing way from all similar products or services."

On a 'standard' construction project, the parameters of the project as an activity are fairly clearly defined, regardless of the choice of procurement path selected. Responsibilities and Risk are agreed for the design, the construction, the successful completion and handover, and to a limited degree, the initial operation of the asset. It is recognised that as the above definitions state, no two projects are the same, and this extremely simplistic view of the project life-cycle takes no account of the technical and managerial complexity which are more common on a modern construction project. There seems little doubt, and clearly obviated by the term itself, that new build is not a difficult concept to grasp, or as defined by Riley and Cotgrave (2005 pp.5), a new build project could be:

"…any work that is starting from scratch…no part of the structure left on site."

Refocusing on refurbishment, the Collins English Dictionary (1989 pp.1285) offers the following definition:

"To make neat, clean, or complete, as by renovating, re-equipping, or restoring"

Although succinct, and in general terms wholly accurate, such a definition is severely limited in scope in describing what Quah (1988) refers to as an area which has evolved a contextually fluid and multi-faceted nature. This approach is supported by Mansfield (2001) who recognised in excess of 20 differing terms that are used to describe the process, which it may be suggested with some confidence, are connected to the reasons for refurbishment. Such a broad range of definitions and interpretations is signposting therefore (in very clear terms), that a process which has capacity to review multiple, and often competing, criterion, is a preferred way forward for the research design, and the conceptual prototype.

2.3.2 The Range of Refurbishment Activities

Although attempting to *define* refurbishment is clearly critical in framing the entire research. The vast amount of literature, articles, or digest submissions, is unequivocal in highlighting to the researcher that there is no hard and set rule on categorising or standardising refurbishment as a term.

Given this challenge, the literature review recognises the need to identify the range of definitions synonymous with refurbishment, and then to translate them into their technical descriptive functions. The first part of this identification process is presented in tabulated form in Table 2.3.2.

Activity	Summary Description
Reconstruction	The rebuilding of a structure that no longer actually exists
Restoration	Work on an incomplete structure to finish it
Deconstruction	Planned removal of a structure or structures for largely socio-economic reasons (usually larger scale)
Demolition	Removal of an existing individual building or facility
Renovation/Maintenance	The maintenance and upkeep of the value and function of the existing building. There is no scope for addition of new aspects within this process.
Repairs/Maintenance	Primarily concerned with the replacement and/or repair of defective building components to keep the building in the same state
Refurbishment	This term in itself requires more detailed discussion and is given following this table.
Conversion	Refurbishment extended to intervention on aspects of the load bearing structure.
Gutting/Rebuilding	Large scale works, very often consisting of façade retention only.
Modernisation	Closely aligned to the 'drivers for refurbishment', this may be the result of evolving legislation or changing regulations.
Decontamination	Disposal and elimination of hazardous substances or materials (asbestos being the most obvious candidate)
Extensions/additions	A new structure connected directly to the existing building
Fitting-Out	Works carried out within the finished frame or 'structural carcass'
Change of use	Self-explanatory. An example being a conversion from an industrial building into apartments.

Table 2.3.2. The range of activity definitions synonymous with the term "Refurbishment" (Adapted from Giebler et al 2009 pp. 11 – 15)

The 'summary description' of refurbishment shown in Table 2.3.2 refers to a separate discussion of refurbishment as a stand-alone activity. It is not enough to consider refurbishment as a 'one size fits all' process, as this is clearly not the case as widely supported throughout the literature and the literature review. Again; it is suggested that a degree of technical measurement or classification is essential to separate the scope of the activity. Giebler et al (2009) offer a fairly simplistic categorisation in identifying:

- Partial refurbishment
- Normal refurbishment
- Total refurbishment

Although an informed 'guess' may be fairly accurately attempted in describing each of these, there is a clear lack of detail, especially in identifying the interface between each activity level. An ideal example of why this definition of refurbishment scope, or scale, is essential, may be best evaluated within the issue of a projects BREEAM Assessment. In the UK, there are mandatory requirements for certain buildings (in this case, Healthcare – institutional) to achieve a minimum BREEAM rating, dependent upon whether it be a new build, a major refurbishment, or a minor refurbishment. This is related to the value of the project, but in general terms the new build project will require an *Excellent* rating, the major refurbishment a *Very Good*, and minor refurbishment not currently rated.

Focusing on the refurbishment classifications, the potential cost, time, and feasibility implications of achieving a *Very Good* rating, as opposed to a no rating requirement is understandably a priority issue relating to the potential success or failure of the project as a whole. Given the critical need to understand the scope interfaces, the *Building Research Establishment* (BRE) has a clear definition within the internationally recognised and accepted *BREEAM Healthcare Assessor Manual* (2008) separating the activities as:

Major refurbishments to existing buildings

For the purposes of a BREEAM assessment, a major refurbishment project is a project that results in the provision, extension or alteration of thermal elements and/or building services and fittings.

- *Thermal elements include walls, roofs and floors.*
- *Fittings include windows (incl. rooflights), entrance doors.*
- *Building services include lighting, heating and mechanical ventilation/cooling.*

It may be argued that this is also a simplistic definition of refurbishment, but the key issue apparent is the translation of the designation into measureable technical terms, which may be factored into any proposed works or design. Nevertheless; the placing of the BREEAM assessment in context, and understanding its effect of the decision making process in hospital refurbishments, is a critical issue, and is identified at this early stage, as being an important data requirement form the future sample population, in primary data collection terms.

Continuing with the requirement to translate the technical descriptive functions surrounding refurbishment as an activity, it is instructive to evaluate the activities themselves in terms of interventions. Understanding what Douglas calls the "range of interventions" (Douglas 2006) A more cogent approach to the connection between the type of refurbishment and the requirement is required. This is best represented by placing the refurbishment related activity, within a framework of hierarchy and time (Figure 2.3.2

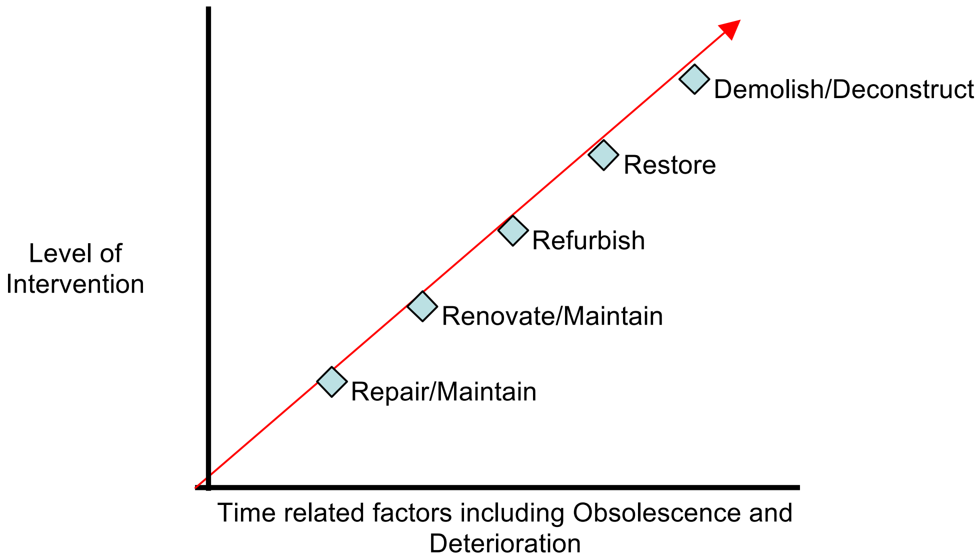


Figure 2.3.2. Demonstrating the placement of the refurbishment 'activities' within the context of time and level of intervention required. (Adapted from Douglas 2006 pp.3, and Giebler et al 2009 pp.11-15

2.3.3 Drivers for Refurbishment

Having considered the approach of identifying the reasons to refurbish and the technical categorisation related to such, there is a subtle, yet important point to be understood in assessing the *type* of refurbishment employed. The differing types may even be inferred as being fairly self explanatory, as in the findings of Aikivuori (1996) who separated the activity into:

- Corrective
- Alteration
- Optimization
- Pleasure driven
- Opportunistic

Although non-technical descriptions in their own right, these typological drivers convey well the broad spectrum of motivations to undertake the refurbishment of a facility or structure. It is reiterated though, that they do lack the level of detail required to comprehensively understand the real technical or social motivations which catalyse the decision to refurbish. In light of this statement, Aikivuoris generic identifiers can be supported by the more detailed observations given by Hardcastle *et al* (1997) in defining refurbishment as:

"…work which involves the structural alteration of buildings, the replacement of main services or finishes and/or the improvement of floor space, and also any redecoration and repair work."

Hardcastles observations clearly support the earlier recognition of the need to interface the refurbishment activity, even within itself, as demonstrated by the BRE definition. (BREEAM Healthcare 2008)

It is significant at this stage to highlight that, although there is a sizeable canon of research into the area of refurbishment (and its wide range of definitions), the historical context of research touches only lightly on *legislation* and *regulation* as core drivers.

In his comprehensive work, Douglas (2006) makes the point that regardless of degree affected, all buildings will eventually be subject to some form of inefficiency or obsolescence. He goes on to describe this in terms of a buildings failure to meet the requirements of either the user, or the changing statutory requirements. This practically 'mandatory' requirement to change and adapt is of especial significance in relation to the hospital, as it highlights the architectural school of thought that 'institutional buildings' *especially* seem designed specifically to resist change (Brand 1994). The philosophy continues, with some merit, to suggest that when forced by circumstances to change anyway, the building (almost as an entity) does so with "expensive reluctance" and the institutional building is "mortified by change". This in itself is a valuable observation in respect of the study of sustainability in relation to the hospital building, as the prominence of the social and the economic aspects are clearly demonstrated, as opposed to the better known, and arguably most anticipated, environmental approach.

For continuity therefore, the literature review identifies that the *fundamental* questions regarding the undertaking of the refurbishment activity may be simplified as:

- When (or alternatively, why) to refurbish?

- How to refurbish?

These highly simplistic 'self-posing' questions capture the very base level of considerations, and yet, there is a process of integration contained within these two points which leads to the necessity to understand the unique characteristics of the refurbishment process in contrast to the 'standard' new build construction.

2.3.4 The Challenges of Refurbishment

One of the most often cited challenges for refurbishment as opposed to new build, is the inherent uncertainty of the works themselves (Egbu & Lee., 2006) (Azlan-Shah., 2010) (Quah., 1988) (Aho et al., 1998) This uncertainty is measured against the process as a whole, but it must be noted that the challenges faced in this aspect also have singular significance, respectively, to the design team, and to the contractor carrying out the works. Perhaps the most obvious example of this (from the perspective of the designer) is the lack of information on the composition or co-ordination of the existing facility or structure. The literature supports the view that designers may be extremely reluctant to commit and engage with the decision making process when faced with the possibility of making mistakes on the basis of insufficient information (Beyond, 1990), which in turn, feeds the perception (Bibby et al 2003) that "most of the time…" construction projects are hindered by lack of performance on the design process.

This issue, which may even be perceived as a source of conflict between the design team and the contractor, is exacerbated by the common (and arguably reasonable) practice, of designers including contingency cost allocations within the design (Rayers and Mansfield, 2001) This anticipates one of the refurbishment projects main challenges, which is the occurrence of large numbers of variation orders to the project, due to the 'unknown' nature of the facility or structure in question.

Despite the technical challenges involved in the refurbishment process, especially in the area of existing services, and the space constraints of upgrading to modern standards and "matching up" (Azlan-Shah, 2010) of the refurbishment output to the existing building conditions, a refurbishment project may have to remain fully or partly operational throughout the project life-cycle. The most obvious impacts of this crucial point are in the area of health and safety, by means of re-routing, and interface with the public, and the potential costs added to the works to facilitate this. (Riley and Cotgrave, 2005) On a 'standard' new build project there would very likely be a fully enclosed site-hoarding, and all persons entering the works area would undergo some form of induction or awareness safety training. When issues such as the potential for dangerous materials (i.e asbestos), the presence of noise and dust, or even the movement of vehicles and plant are taken into consideration, the unique approach required by all parties to the refurbishment process becomes more pronounced. Additionally, clear direction is shown at this stage, for the importance of ranking and prioritizing the criteria of a functioning decision support prototype. These over-lapping challenges and activities, will form the basis of the ranking and weighting functions discussed in Chapter 6.

The remaining points to be understood for a rounded appreciation of refurbishment as a whole, are the earlier questions posed of 'when (or why) and also 'how' to refurbish. The answer to 'why' has already been touched upon in the earlier discussion on defining refurbishment, and it may be fair to say that different building types will have differing drivers to instigate the refurbishment process. Regardless of individual differences, an immediate and fairly summarised suggestion is offered by Markus (1979), who states that...

"The overall purpose of refurbishment is to extend the beneficial use of an existing building by providing a cost effective alternative to redevelopment"

It may be argued however, that this explanation does not go far enough, and its logical simplicity ignores important detail in regard to both functional and economic aspects. Mansfield (2009) specifically identifies depreciation as a main driver in the decision making process. His observations address the connection between the reduction (or loss) in value of the properties investment value (in terms of both rental and capital), when compared to the value of a new property. He continues to identify that depreciation itself is a result of two further 'sub-effects', namely, physical deterioration, and obsolescence. There is validity in the proposition that the physical deterioration aspect of these factors is to a large degree predictable, but his view that the area of obsolescence is both 'unpredictable' and 'impossible to address' is questioned. Given the challenge of the ever-shifting models of care and continual technological advancement associated with the hospital, it is argued that the hospital, of all built assets, must have obsolescence, and therefore adaptability, accepted as a fact and be addressed within the design accordingly. For the NHS as the Client, and the Design Team and consultants, this presents clear challenges. These challenges however, are beginning to provide structure to the conceptual and framework decision-making process. It is apparent, that a robust, yet flexible, methodology is required, which offers the decision maker choice and adaptation possibilities.

2.4 The Hospital in Context

Hospital: *An institution providing medical treatment and nursing care for sick or injured people* (Paperback Oxford English Dictionary 2010)

In the perception of most, if not all, observers, the above definition is irrefutable. The definition does indeed address both the fact of *form and function*. However, accurate as this may be, it is argued that this description is woefully inadequate in capturing the modern diversity and dynamism that the hospital, as an institution is. Miller (1997) goes further in defining the hospital as…

"…an institution which provides beds, meals, and constant nursing care for its patients while they undergo medical therapy at the hands of professional physicians. In carrying out these services, the hospital is striving to restore its patients to health."

Millers definition begins to illustrate the multi-functional nature of the hospital, in his reference to the accommodation (beds) and catering (meals) aspect of the institution, and demonstrates the progression from the almost alien perception of relatively recent times that the hospital was no more than a "warehouse for the sick" (Miller and Swensson 1995), or as even the Victorians grimly considered them, places to go and die. This is an extremely significant point, as for a comprehensive research on any area or facet of the hospital, it is deemed essential to firstly, understand the scope and scale of the structures, the models of care, and the functions therein.

2.4.1 Defining the Hospital

In the attempt to define the hospital, and as touched on above, this is not a straightforward task. It may be argued that the hospital is like no other building in current society, and aside from the unique functional characteristics of a building that never closes, and has the capacity to incorporate every other building type within it. In addition, there are critical functional issues, ranging from supporting infrastructure, to routing and circulation areas. These are shown in Figure 2.4.1a as satellite functions around the main hub of the hospital as an integrated facility.

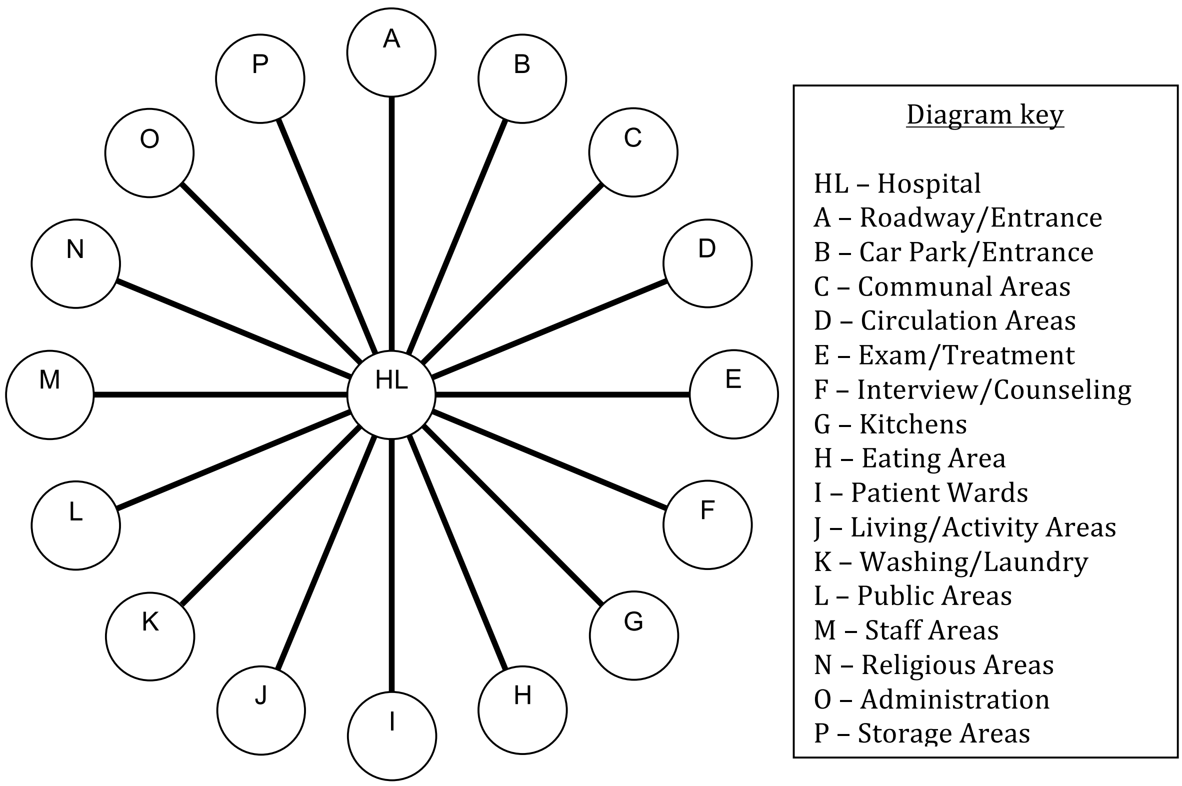


Figure 2.4.1a: Functional characteristics of the standard acute hospital. The diagram shows the main aspects as 'satellite' functions around and within the hospital as an integrated 'hub' facility.

There also exists the wide diversity of service provision, based on current (and evolving) models of care. This is in addition to the powerful social aspect of the facility and as Rechel et al recognise, the hospital is quite often viewed as a symbol of civic pride, and even as a measure of success of the welfare state (Rechel et al. 2009)

Expanding on the above reference to the 'evolving' models of care, this single issue may be suggested as *the crux* of the challenge in attempting to define a boundary around the concept of a hospital, and the resultant requirements of the facility itself. This is evident in the transference of treatment in many cases from the more traditional secondary care, which would involve attendance and treatment at the hospital itself, to that of a primary care setting, whereby treatment and advice is offered at the general practitioners surgery (or clinic), or in the patients home.

The hospital (or hospital system) is itself driven by factors outwith its control, as illustrated by McKee et al (2002) who recognize what they term, *demand-side* changes, such as ageing populations and changing patterns of disease, *supply-side* changes, incorporating the effects of technological advancement and workforce structure, and the *political and societal* changes which are especially relevant in regard to NHS England and the passage of the *Health and Social Care Bill 2010-2011* (HM Government. 2011) which seeks to completely redesign the management structure of the previous system. The Bill outlines the abolition of the previous systems of Primary Care Trusts and Strategic Health Authorities, and (perhaps more controversially), placing greater financial powers and responsibility directly into the hands of GP consortiums to allocate their own resources and commissioning of services.

In time, this may prove to be a crucial factor in the consideration of hospital design and refurbishment, as the institutional reforms may represent a quantum shift in the treatment of patients and models of care provision. The current UK government did have a level of support base for pushing through the Bill and it's reforms, yet as far back as 2002, McKee and Healy (2002) discussed this very issue in the context of its implementation in the former

Soviet Union with the result that, although such a system did provide some merit (in the sense that hospital managers and clinicians are well placed to know 'what is best' for the hospital), the change in 'encounter' between the patient and the health professional ultimately led to 'deprofessionalisation' and a degraded quality of service.

Drawing the focus back from these wider social considerations, the hospital (using as a reference project, the commonly recognised acute facility) is still after all a built asset occupying a definitive footprint and corresponding three-dimensional projection in space.

Given the nature of the facility, it can be confidently stated that there are a wide array of specialist equipment necessary to the unique nature of medical care, and yet, as with any other comparable (in size) building, there are nevertheless constant and standard features of the constructional components (Figure 2.4.1b).

It is instructive to consider that each of the example components shown has some form of environmental and sustainability linked impact. This may be especially significant in regard to the refurbishment process, which has capacity for a complicated range of intervention opportunities with components in question. What may complicate this commonality is not the *form* of the asset, but the *function.* Perhaps the most obvious example of this being the issue of *Hospital Acquired Infection* (HAI) which has cause to separate each and every component from it's 'standard building' counterpart, from the earliest design and specification stage. How these issues are interpreted and ranked by the decision-making teams responsible for the refurbishment and maintenance of the hospital, will be a key consideration for the prototypes design, but also the composition and data requirements of the primary data collection exercise.

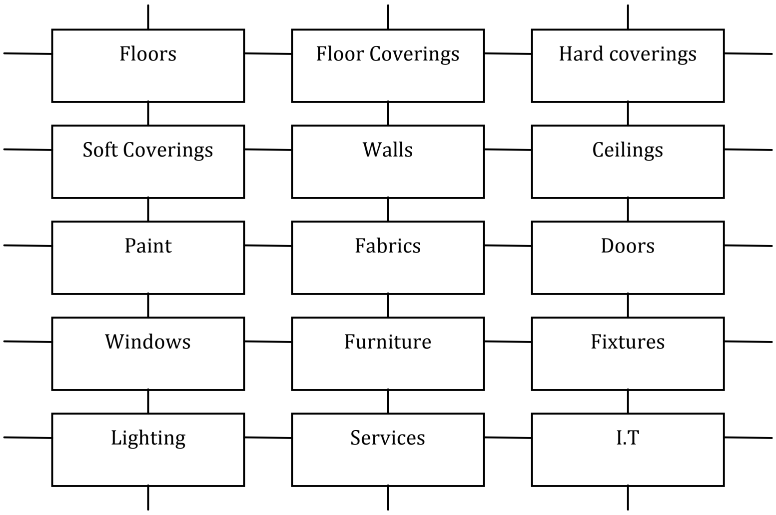


Figure 2.4.1b: Component and Element characteristics of the standard acute hospital. The diagram shows the components as an open matrix to highlight the integrative nature of the collective characteristics.

2.4.2 Economic Challenges for the NHS

The NHS, as a publicly funded institution is facing great challenges in light of the current UK economic downturn. Current predictions on financial pressures in England suggesting a 4% decrease in funding every year, over a period of 4 years (BBC News Online 2010) equating to a 'real' cash figure reduction of between 15 and 20 billion pounds. Scotland has a similar tale with the public sector watchdog identifying the NHS in Scotland as facing an "unprecedented squeeze" in its budgets and finances (Scotsman Online 2010) Although not inclusive of the entire United Kingdom, it seems reasonable to assume that these predictions are indicative for the NHS as a whole, and are likely to have a significant impact in all parts of the country.

In appreciating the effects of such a major 'efficiency drive' on a national level, it is important to view the NHS in perspective of scale. This is most easily conveyed through basic statistics of the healthcare portfolio and the staffing levels. The portfolio of the NHS identifies it as the largest public sector body, not only in the UK, but across the whole of Europe (NHS Sustainable Development Unit 2009). Direct staff employment is correspondingly high, with an estimated 1.3 million people directly employed. (NHS Jobs 2011) These figures take no account of the indirect employment figures related to areas such as infrastructure, retail, and supply chain.

Overall, there is an extremely broad array of functions, departments, and business drivers which have evolved as essential to maintaining and supporting the service in its present form. This very evolution may be related to the core value of the NHS, which may be identified as the provision of care and services. It would be difficult to argue the point, that this is in fact the fundamental raison d'être of its very existence.

2.4.3 Changing Demographics and Models of Care

At its most functional level, the healthcare system and the hospitals within it must be measured against the issue of 'provision of care'. This in turn is framed within the ever 'shifting sands' of service provision by process, and service provision by requirement. What must be understood by this statement is that the process, or method of service provision, is in itself a moving target. This is further compounded by the increased 'blurring of the lines' between the traditional roles of primary and secondary care (Black and Gruen 2005).

In regard to the issue of service provision by requirement, it is now widely understood that there have been significant changes in demographics (McKee and Healy 2002) which has observed an increasingly ageing population, and a range of medical conditions and diseases which are relatively new on a national level, attributable to such factors as strain resistance and re-emergence of previously controlled conditions (Gaydos and Veney 2002). This observation must also be expanded to include the growing increase in numbers of people suffering from obesity and dietary related conditions, (Rechel et al 2009) and to the conditions which accompany an ageing population, which includes the need for growing requirements for high maintenance residential care and the increase of co-morbidities (Chaudhary et al 2006).

In design and construction terms, an additional perceived danger, especially in relation to new build projects, is that aspects of the built asset may be overtaken by changing requirements by the time the hospital is operating, or certainly before the envisaged end of life (Rechel et al. 2009) This may not necessarily be solely as a result of demographics or service provision, but also as a result of technological or medical advancement, which could ostensibly render a facility or aspect of a facility obsolete. This is phrased well in Rechel et als observation that "form follows function" (2009) and highlights the argument that a hospitals design is challenged by the need to address future events and trends, and its configuration should, in theory, be determined with this in mind. Given the economic challenges, and the nature of the design and construction process, this presents an uncomfortable interface between the NHS and the design and planning of its built assets. In turn, this supports and justifies the research objectives, in exploring and developing an interface point, that addresses this discomfort, by the use of a ranked, weighted, and structured process.

2.4.4 Researching the Hospital

In continuation of the earlier social and political considerations, and in direct relation to Edwards and Harrisons (1999) still valid observations that there exists a limited amount of research into the relationship between hospital design and service delivery requirements, the full quote from Hillmans journal article *Restructuring Hospital Services*, (1998) is presented below as a thought provoking analogy to the challenges and even dangers of restructuring in the context of healthcare and service provision.

"A new drug cannot be introduced…without exhaustive scientific trials, but we usually introduce new ways of delivering health services with little or no scientific evaluation. We rationalise, change and formulate new systems, often based upon economic and political imperatives, and yet rarely evaluate their impact upon patients. Significant morbidity and mortality may be associated with new models of healthcare delivery. If healthcare changes were submitted to the same scrutiny as new drug evaluations, they would probably not even be allowed to move from the animal to the human experimentation stage."

So it seems evident that in defining the hospital, it is essential to *understand* the hospital. It could even be argued that given the vast scope of functions and services, and the correspondingly vast scale of the NHS as an institution, it may not even be possible for any single person to fully understand the almost byzantine connectivity's and relationships involved. In this case, the best that can be achieved is to at least *appreciate* that the hospital is the incredibly complicated result, of a very simple idea.

2.5 Hospital Refurbishment and Sustainability

As the title of this section heading implies, considering the activity of hospital refurbishment within the context of sustainability is in itself an integrative approach. In addition to the technical, financial, and social issues which must be factored into the discussion, there are regulatory and legislative drivers which must guide and direct compliance. This is further solidified by a need to understand and interpret the Clients needs for the facility. In capturing all aspects of the sustainability issues related to the hospitals place in the public sector, the Director of the NHS Sustainable Development Unit, Dr David Pencheon, made special reference in his consultation response (2010) on 'Healthy Lives, Healthy People' to the sixth of the NHS seven guiding principles with the reminder that:

"The NHS is committed to providing best value for taxpayers money and the most effective, fair and sustainable use of finite resources"

This is recognised as a major challenge for not just the NHS as the Client, but also the design teams and contractors in delivering and maintaining a built asset as multi-faceted and complicated as a 'standard' acute hospital. In the context of sustainability alone, these challenges are illustrated in Table 2.5, which separates many of the core sustainability considerations beneath the wider overarching drivers. What is clear from the factors within Table 2.5 is that there are multiple instances of a particular issue being grouped under more than one, or sometimes all of the three component parts of the sustainability model. This is a good indicator of the integrated nature of the hospital as a whole in regard to the issue of sustainability, and the integrated nature also, of the sustainability model itself and crucially, the necessity to build this into the prototype. Although integration may be considered in very positive terms, especially in regard to a team approach and the related synergies resulting from this; the hospital also presents unique challenges which have potentially the capacity to view integration as much a part of the problem as the solution. Perhaps the most basic example to demonstrate this point is the issue of Healthcare Associated Infection (HAI). Practically every factor within Table 2.5 must be considered against the prevention of HAI as a priority, as discussed earlier in the review. It is recognised that a 'standard' commercial building has health related issues in regard to material selection, water supply etc., but the potential consequences and associated regulation and demand for best practice, place the hospital in a challenging and demanding league of its own. The connection between multiple drivers and a wide range of individual criterion, discussed later in Chapter 6, is becoming far more pronounced.

<table>
<tr><th colspan="3"><u>Overarching Considerations</u></th></tr>
<tr><td colspan="3">Legislation
Demographics
Changing models of care
Planning issues/requirements
Sustainability Drivers
Funding
Political ideologies
Technological advancement
Climate Change</td></tr>
<tr><th><u>Social</u></th><th><u>Environmental</u></th><th><u>Economic</u></th></tr>
<tr><td>Therapeutic Environment
Reduce Risk of infection
Thermal comfort
Fresh air provision
Natural daylight
Environmental control
Privacy & dignity
Acoustic quality
Art & Colour
Adaptability
Transport
V.O.C
Array of room types
Procurement
View out
User groups expectations</td><td>CO2 Emissions/Reductions
Waste Management
Reduce/Reuse/Recycle
Embodied Carbon
Climate Change
Adaptability
Specification
LZC Technologies
Transport
V.O.C
Array of room types
Procurement
Water use and Consumption</td><td>Life Cycle Costs
Whole Life Analysis
Reduced Energy usage
Reduced absenteeism
CRC Energy Efficiency Scheme
BREEAM requirements
Adaptability
LZC Technologies
Transport
Array of room types
Procurement
Staff retention
Ageing population and co-morbidities
Modern health issues and impacts (obesity etc.)
Water Use and Consumption
Waste management
Specification</td></tr>
</table>

Table 2.5: Core Sustainability considerations within the wider Sustainability model. Framed within the overarching drivers for Sustainability, the table demonstrates the integrative nature and duplication of specific aspects across the 3 component parts of the model

2.5.1 The Current Position

It is important to highlight at this point, that despite the identification of the challenges, and the setting of targets in regards to sustainable healthcare (assets and delivery), the issue is not clear-cut. An added complexity to the issue, which will add to, the overall challenges already faced by the NHS relates to the constant shifting of problem parameters. To illustrate this, if the nature of the investment and expansion to the NHS estate over recent years is considered, it can be seen that this has resulted in an overall increase of CO_2 emissions of 40%, measured against the 1990 baseline (NHS Sustainable Development Unit 2009) This is despite the increased efficiencies achieved through strategic and operational reorganization. This has the significant impact of requiring not only the reduction in emission production, but also a trend reversal of the factors contributing to the overall footprint *at source.*

This correspondingly high increase in CO_2 emissions which seems to overtake and negate the real progress being made presents an almost 'Catch 22' situation. This however, is viewed by much of the community and industry practitioners as *the challenge* in regards to the healthcare sector, and the key to understanding and managing the issues concerned, is rooted within the data and statistics available.

2.5.2 The NHS and the Sustainability Agenda

The current status of the NHS in terms of sustainability is quite telling to appreciate (as discussed earlier) that the NHS possesses Europe's largest property portfolio, and in consequence of this, it is credited with 3% of total UK CO_2 emissions (NHS Sustainable Development Unit 2009) The scale of the portfolio has the knock on effect of identifying the NHS as the largest single contributor to climate change in the public sector (Health Estate Journal 2010) In numeric terms, the annual emissions are estimated at 21 million tonnes of carbon. (Health Estate Journal 2010) In its simplest terms, it should be understood that for these emissions to reach the end process of atmospheric release, the energy or fuels at the root of the emission must be consumed in the first instance. This consumption in turn generates a real financial cost, which is estimated to be in excess of £400 million per annum

(Carbon Trust 2010). The connection between economic and environmental considerations, viewed in these simplistic terms seems unambiguous.

2.5.3 The Issue of Carbon Reduction in the Healthcare Estate

Identifying the areas of emission is key to this process and figures have been published recognising (in England) the breakdown of the carbon footprint as 22% in energy use, 18% in travel, and 60% as a result of procurement. (Carbon Reduction in the NHS: a role for finance 2009) By comparison, Scotland's figures are calculated as 23% energy use, 25% travel, and 52% in procurement. (Health Facilities Scotland. 2009)

In terms of action, the legislative and financial drivers must be considered in the context of implementation and timeframes. Although the countries within the UK have differing details in respect of targets there remains nevertheless, a shared requirement to reach the 2050 target of an 80% reduction in emissions calculated against the 1990 baseline.

2.5.4 The Hospital as a Sustainable Asset

The significant observation by Sheth et al (2008) that that the majority of the existing healthcare built assets which will be utilised well into the 21st century have already been built, must direct the research to consider these factors in considering the procurement, design, and refurbishment of existing facilities. This observation is framed within the expectancy of future requirements from the NHS, as stated by the Chancellor of the Exchequer in his statement that all government departments and the NHS must now (from April 2011) meet a mandatory requirement to publish a sustainability report in their annual accounts. These are to include details of not only carbon emissions, but also waste management, and the use of finite resources (DEFRA 2011) By the nature of the construction process, which will include the design and construction phases of refurbishment activity, these issues are especially relevant and have regulatory and management aspects which are unlikely to be found on a similar scale in any other industry and it is this more holistic methodology which is key to understanding and modeling an integrated approach. Rechel et al (2009) provide a number of key themes in the construction and refurbishment of healthcare facilities (see Figure 2.5.4)

These issues are inclusive of innovative design, therapeutic environment creation, response to future changes, the whole life cost analysis, and the carbon impact and rating.

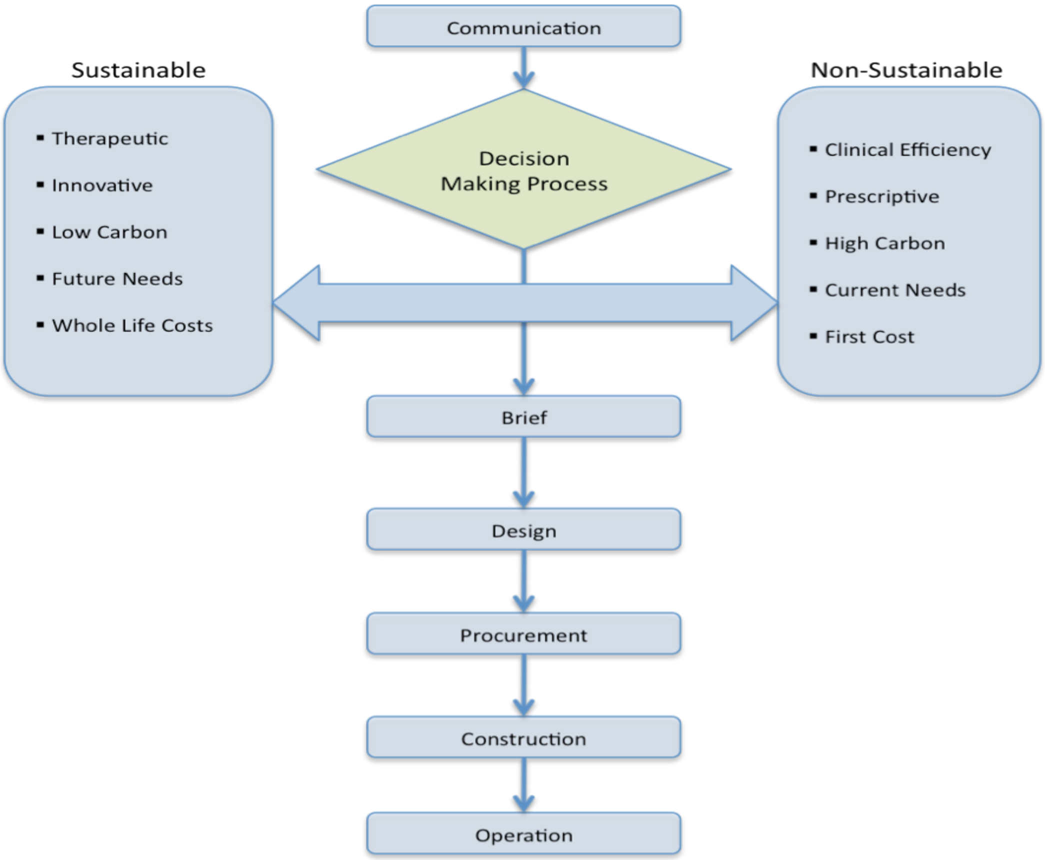


Figure 2.5.4: Key sustainability themes (adapted from ARUP Healthcare Design Group) Rechel et al. 2009 Investing in Hospitals of the Future European Health Property Network. pp.230

The issue of perception and understanding of what sustainability means, and how to define it, become prominent in this context, to provide a frame of reference for the relationship between the hospital and sustainability. Gibsons model (Gibson 2006) consisting of the well-known Venn Diagram showing the tripartite and integrated nature of sustainability is still valid. However, the hospital by the nature of its unique characteristics (including the process of refurbishment) must have the flexibility within the model to address its specific needs and requirements.

2.5.5 The Requirement to Consider Adaptation

It has been discussed previously, in section 2.2.4 that the issues of climate change, and the potential effects of the phenomena on the built environment, must be considered as a continuum or scaled process (and it was stated also, that this will be applicable to the conceptual models design discussed in Chapter 6). The understanding and placement of context is critical to the identification of a problem goal, which itself is a fundamental requirement for the successful implementation of the eventual decision making activity. Decision making in these terms is a critical process and will be explored in detail, later in the thesis. When considering *adaptation*, a similar 'scaled' approach must be undertaken. In terms of both climate change and the built environment, the contextual positioning of adaptation requires clarification, again, on a macro and micro level. In the context of 'a' facility or building, Douglas (2006) defines adaptation as…

"…any major works to adjust, reuse or upgrade a building to suit new conditions or requirements"

This is a very 'asset specific' description, and it must be noted that the similarities with the drivers and activity surrounding 'refurbishment' bear similarities. The integration of adaptation and refurbishment will be considered in the next section, however, at this stage, the review focuses primarily on adaptation as the foundation to this. In this context then, and regarding adaptation, a purely physical activity is described that may be planned, designed, and constructed within the normal parameters of the 'standard' project management and procurement processes. Adaptation of a single facility however, has the capacity to fail on an infrastructure basis, when measured as part of an integrated approach as described previously. Boyd and Tompkins (2010) illustrate this potentially myopic approach with the example of a property owner constructing a seawall to protect their facility against 'wave attack'. This is measured as a success in terms of a singular project, however the redirection of tidal energy may have the effect of increasing the severity of erosion further down the coast on multiple facilities or properties. From an integrated and sustainability focused standpoint; could the original adaptation project still be considered as a success?

In the context of infrastructure, and accepting that regardless of the argument on the *causes* of climate change and extreme weather events, the definition and understanding of adaptation must be 'up-scaled'. Various definitions exist in the literature, however the following, taken from the *Organisation for Economic Co-operation and Development* (2006) are suggested as identifying and encompassing the main aspects.

1. *Adjustment in natural human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory or reactive adaptation, private and public adaptation, and autonomous and planned adaptation* (IPCC 2001)
2. *…a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented* (UNDP. 2005)

Adaptation in these terms is a far more strategic endeavor. The adaptation of the stand alone facility or building as described by Douglas (2006) is critical, and yet, as with the issue of healthcare provision in 'infrastructure stressed' scenarios, it is the 'downstream' or 'end' aspect of the greater whole. Despite this linear separation, there is no significant distance between the strategic adaptation requirements, and the physical adaptation methods employed at facility level. This is an important point that is made, in terms of designing an integrated decision support function, and as will be shown on the actual development of the prototype section in Chapter 6, a model which may be iterated using exactly the same methodology, and different *only* in regards to *scale*, will be of great benefit. Figure 2.5.5 shows Boyd and Tompkins (2010) 'eight elements' of an adaptation strategy. When these are considered against the 'usual' requirements and processes involved within the construction (or adaptation) of a major public infrastructure project such as an acute hospital, it can be seen that the differences are in fact slight, and only differ on most elements in regards to scale.

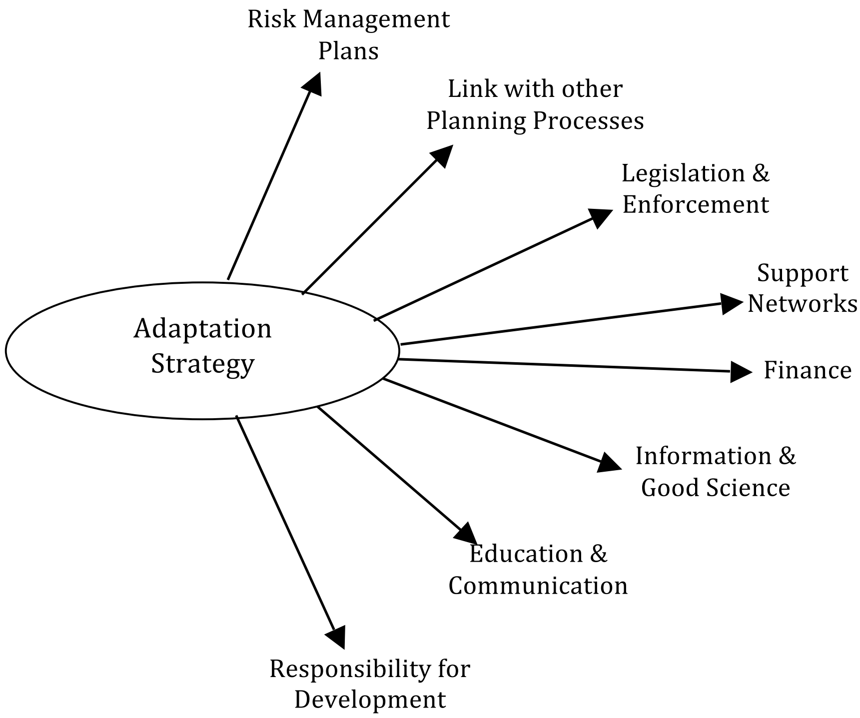


Figure 2.5.5. The eight elements of an adaptation strategy (Adapted from Boyd and Tompkins 2010 pp. 85)

What Figure 2.5.5 demonstrates (aside from the actual strategy and sub-strategies involved in the adaptation management process) is the introduction, and importance of, management tools in the area of sustainability measurement and management in the context of healthcare infrastructure. Again; the point is highlighted regarding the differences, yet similarities between adaptation and refurbishment, and the presentation of both throughout the literature encourage an integrated approach in considering them. It can also be argued that 'vulnerability' is included within this aspect of the discussion, as being another related activity and philosophy of the wider refurbishment debate. All of these are explained in greater detail in a later section. Prior to this, it supports the literature review to consider adaptation (or adaptability) in a stand-alone section in the context of healthcare.

2.5.6 Healthcare Infrastructure and Adaptability

It has been suggested previously, that the hospital is the 'key' physical asset representing one of the main infrastructure services (i.e. Healthcare). What places the hospital within a demanding league of its own, and sets it apart from other infrastructure assets, are the 'functional requirements'. These requirements differ from the majority of infrastructure networks in the sense that the pressures placed upon healthcare facilities are multi-faceted, whether in the context of an extreme weather event or the susceptibility to the more gradually evolving effects of a changing climate. This is most clearly understood by the appreciation that in the first instance (and shared with all other infrastructure assets), the building itself is vulnerable to the effects of changes in climate and weather patterns. These effects are both external and internal in nature (for example, building fabric performance and indoor environmental quality) but are broadly driven by the same factors identified by Oven et al (2012) of heatwaves, coldwaves, floods, and storms. Secondly, and uniquely, the hospital by its nature must have the capacity to treat those affected by climate related effects. This itself is a double-edged sword, in the sense that the built asset must have the capability to provide a clinical or recuperative environment (such as cooling for heat related injuries), and also that the clinical *models of care* are flexible and resilient enough to deal with medical situations as they arise. This demands that the hospital as an asset, and the provision of effective healthcare as a service, presents a critical requirement to model the integrated nature of both in the face of complex adaptation requirements. Given the number of variables associated with the hospital, and the rapidity of changes in both treatments and conditions, it is therefore surprising that the challenge of adaptation to date, has largely focused on domestic or commercial premises (Manewa et al 2010) (Gibb et al 2007) driven primarily in terms of economic evaluation. This also contrasts with Boyd and Tompkins (2010) eight required elements for an effective adaptation strategy shown in Figure 2.5.5. Carter (2011) takes a wider view, and suggests that across Europe, adaptation requirements present a 'very low priority' for city planners and governors. There are regional exceptions, such as Madrid, Manchester, Basel, Freiburg et al, but given the fact that circa 75% of Europeans live in urban areas, a figure predicted to rise to 80% by 2020 (EEA 2006), this apparent reluctance to engage on a city or national scale is perplexing.

2.5.7 Integrating Refurbishment, Adaptation, and Resilience

Adaptation of the healthcare estate has been considered so far, mainly in the context of strategic planning requirements. However, referring back to Douglas's (2006) definition of adaptation specifically in the sense of the physical built asset, it naturally follows that strategic plans must ultimately equate into physical works or actions. An understanding of the relationship between adaptation and refurbishment is a key point, and Douglas (2006) recognises this in placing refurbishment as a 'level of intervention' within the overall adaptation process. Markus (1979) highlighted the …'unhappy confusion' of terms used interchangeably when considering building adaptation, refurbishment, alteration, or maintenance. At face value, this distinction might be considered as merely an exercise in semantics, however the legislative, regulatory, and funding requirements of capital release on hospital refurbishment projects (certainly within the United Kingdom) are highly prescriptive in nature. The scene seems set then, for focusing on these well-understood challenges, and using them as a basis for the parameters of a robust and functioning prototype, or model. The current assessment model used (predominantly) in the UK, is the BREEAM assessment tool currently addressing what it terms 'major refurbishment' projects. The criteria identifying a major refurbishment are offered as…

"For the purposes of a BREEAM assessment, a major refurbishment project is a project that results in the provision, extension or alteration of thermal elements and/or building services and fittings. Thermal elements include walls, roofs and floors. Fittings include windows (incl. rooflights), entrance doors. Building services include lighting, heating and mechanical ventilation/cooling" (BRE 2008)

There are a number of factors which need considered in regards to the refurbishment activities described within the BREEAM assessment (and guidance) In the first instance, the fact that the UK Government has legislated to demand a BREEAM assessment as a mandatory design and construction consideration may be justifiably viewed as a welcome step in the right direction. The other side of the argument however, also has merit in viewing the success of BREEAM application as part of the problem rather than solution. Stringent legislation and inflexible prescriptive requirements within the assessment methodology impress many practitioners and user groups with the emergence of additional layers of bureaucracy and cost which, when measured against wider sustainability aims, provide negligible effect when viewed through the lens of value versus cost. Implementing adaptability-focused changes to the refurbishment process of an existing facility requires an understanding of the pro-active/reactive connections between the activities and drivers of adaptability, refurbishment, resilience, and vulnerability. Figure 2.5.7 shows the characteristics of these connections.

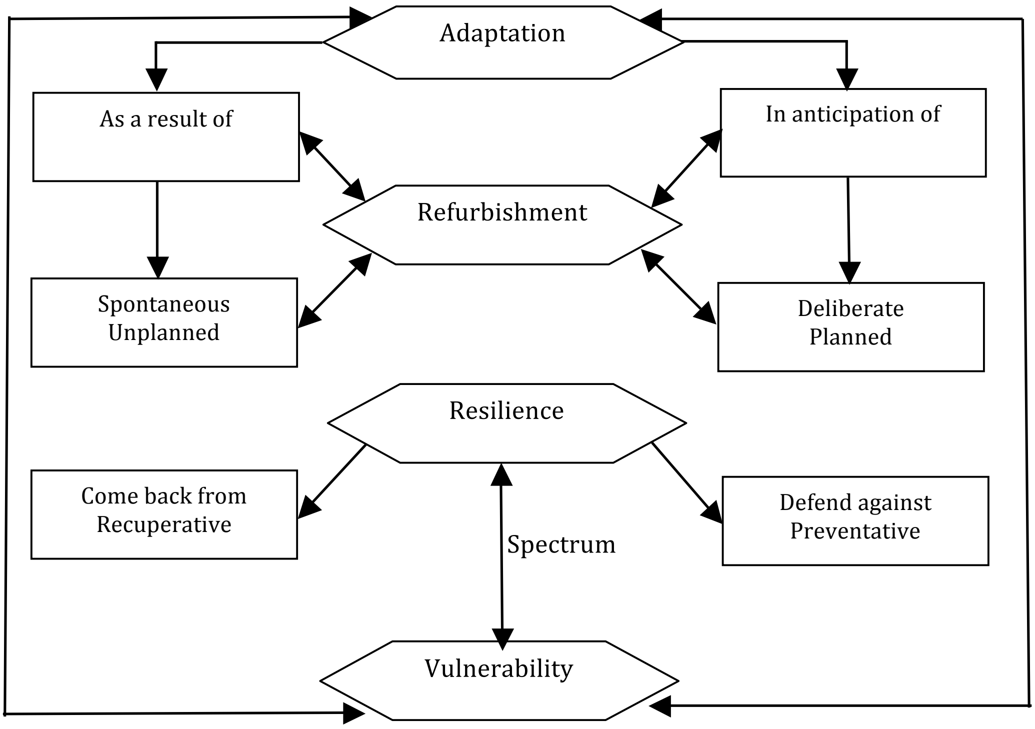


Figure 2.5.7. The proactive and reactive relationships of the structural/facility adaptation process

In terms of finance and resource, it is unrealistic to consider a complete new-build of the existing healthcare infrastructure within an adaptation strategy. Similarly, it is not feasible to carry out adaptive works on every hospital or healthcare facility without the already existing drivers encountered for commissioning a 'standard' healthcare refurbishment project. This suggests that refurbishment may be the only *realistic* physical opportunity for adaptive capacity to be designed and built into existing facilities. Again; using the BREEAM assessment as an exemplar, adaptation does feature through credits such as 'Potential for Natural Ventilation' and 'Flood Risk' but adaptive structural capacity as a *targeted activity* is not recognised as a stand-alone section or set of criteria. Many of the credits within this (and other) assessments, can be placed within the climate change/sustainability loop shown in Figure 2.2.6 earlier in the chapter, but does this target the adaptive requirements specifically enough?

Notwithstanding Markus's (1979) observations on the myriad and often mixed definitions between adaptation and refurbishment et al; in practical terms of securing money from the public purse to carry out adaptive capacity works, and to place criteria within a regulatory framework for Facilities Managers and Contractors, it seems most logical and least complicated to insert adaptation more prominently within the existing processes and methodologies. This approach is clearly discernible within Boyd and Tompkins (2010) 'eight element' requirements (Figure 2.5.5) for an effective adaptation strategy, most notably against the elements of linking with other planning processes, legislation & enforcement, and finance. This is not to say, that the issue of adaptation of the built environment and its relationship to climate change is being ignored. On the contrary, there is a great deal of consultation and discussion ongoing across departments. The Scottish Government (as an example) is arguably one of the most pro-active in their policy commitments, evidenced by publications such as the *Built Environment Sector Action Plan* (SG Online) or exampled more specifically within the healthcare sectors key guidance documents such as the *Property Appraisal Guidance for NHSScotland* (HFS 2010). This last, categorically states that it is a mandatory aspect of the guidance for a climate change impacts and 'suitable' adaptation strategy, to be included as part of the overall environmental management process. How well the individual Health Boards respond to this remains to be seen, however, a common thread throughout the guidance and publications, is the identification of 'the problem', and the identification of the 'requirement' to evaluate and plan for the problem. However no clear strategy or integrated methodology that facilitates the decision making process in selecting and implementing cost effective, and real 'physical interventions' to the existing built healthcare estate, exists (in a formalised and measurable form) This provides an early indication of the requirement for an integrated decision making/management process to be developed.

2.5.8 Assessing the Sustainable Refurbishment of the Hospital

As previously discussed, and shown earlier in Figure 2.5.5, it seems evident that to assess and manage the sustainability focused improvements and/or changes, to the healthcare estate, then suitable management models, processes, or systems must be employed. This part of the literature review will naturally support and integrate with, later discussion on the types of decision making and support models available to the 'refurbisher'. However, in the interests of clarity and linear continuity, it is important to consider sustainability assessment processes in the context of the hospital, in a stand-alone section and sub-sections.

The question, which must be raised at an early stage of the research (in the context of evaluating suitable management tools) is *'what is out there?'*

It seems surprising that the issue of hospital refurbishment has only really gained recognition from an environmental assessment method in relatively recent times. Even so, a detailed review of the literature and the existing tools shows that the issue of refurbishment is notoriously difficult to approach when seeking to attain a grading or certification under any of the existing schemes.

The existence of industry standard tools such as BREEAM for Healthcare (BRE 2008) do address the specific area of refurbishment, yet the application of a credit based assessment may also be perceived as a minimum standard to be achieved by design teams and contractors. What BREEAM does offer however, is an approach that recognises the assessment of both the construction and refurbishment activity, and also the specification directives required to facilitate the buildings sustainability performance *in operation.* This is a significant point, as by the nature of the differences between contractor and client (or end user), the philosophies and business case drivers of all major stakeholders in the project must be fully understood in respect of economic and contractual processes. This is argued as critical if design options and subsequent performance criteria are to be maximized within scope and cost.

2.6 Reviewing Sustainability Assessment Models

The number of Sustainability assessment Tools and methodologies is vast. In addition to this, the scale of assessment may encompass whole countries to individual dwellings. Regardless of scale, most effective systems are based on definite frameworks, which have the capacity to differentiate between indicators, metrics, and specific geographic or cultural aspects for a given assessment. Although essential aspects of a credible and effective methodology, the indicators, metrics, and also the weighting and rating systems applied to the range of tools are the cause of the greatest complexity within them. There is no single 'best fit' tool, and the problem of comparison is compounded by the selective nature of criteria found throughout the numerous international and intra-industry models. In respect of the built environment, there is the additional complexity when comparing the activity of new build against that of refurbishment. Weighting systems and scoring are challenged with the task of creating an equitable and common ground, even when using the same system on each type of project. The research will use these findings, and concentrate of simplifying them for use, without losing any of the efficacy of the weighting and scoring processes. The UK NHS is constrained within legal parameters in its choice of sustainability assessment tools which; given the guidance requirements of the Capital Investment procedure, and against the backdrop of the Climate Change Act, place additional systemic challenges for the future.

2.6.1 Purpose and Function

To understand the need and purpose for the development and use of sustainability assessment models (in the context of this review, the term 'model' and 'tool' are deemed inter-changeable), it is first important to explore the higher-level issue of sustainability assessment as a process.

A detailed historical analysis will not be pursued in reviewing the differing assessment models, yet it can be confidently argued that it is virtually impossible to consider the evolution and growth of sustainability assessment as a process, without reference to the 1987 *Brundtland Report* also known as "Our Common Future" (WCED 1987) This Report, as has been discussed throughout the literature review, was key to setting out and defining the parameters of what is now commonly referred to as 'Sustainable Development' (SD). The Brundtland definition of sustainability has been discussed previously, although Hens (1996) offered a more detailed definition reflecting the integration of the component parts of the widely recognised sustainability model, as presented within the Venn diagram (Gibson 2006) He defined SD as:

…the rearrangement of technological, scientific, environmental, economic and social resources in such a way that the resulting heterogeneous system can be maintained in a state of temporal and spatial equilibrium (1996)

Hens definition then, paves the way for the more formalized and structured methodological approach required to structure a sustainability assessment system and its related models. At a higher level these assessments can take different forms such as the more recognized Environmental Impact Assessment (EIA) or Strategic Environmental Assessments (SEA). Regardless of the particular model employed, it must be understood that there are basic drivers and reasons for the use of these tools at all. To understand this, an even more fundamental appreciation must be attained of what sustainability assessment itself is and what it seeks to achieve. Devuyst (2001) presents sustainability assessment as tools which (initially) aid and direct the decision-making process and provide information required in creating relevant policies regarding sustainable development. This basic 'purpose' should be considered as a key point, as the literature review will identify this same fundamental function as a common denominator on the tools and methodologies from the international level down to the industry, or even structure specific. How the contents and methodologies used within current systems support the research and prototype development, should be clearly seen as the discussion proceeds, especially in the context of criterion identification and scope.

2.6.2 Explaining the Framework

In continuation of the theme of 'commonality' amongst all levels of tools, the literature does generally agree that there are three main categories to be considered within any existing (or proposed) sustainability framework.

Although the labeling may differ slightly, Ness et als (2006) separation of indicators/indices, product related assessment, and integrated assessment tools are offered as one of the better examples of this identification. An added reason for singling out this particular example of an overall sustainability framework model is that it is framed within a temporal focus (Figure 2.6.2) Although pertaining to a framework for sustainability assessment tools 'collectively', this inclusion of a time-line, ranging from the retrospective, to the prospective in relationship to the linear life-cycle process of a construction or refurbishment project, presents opportunities for comparison regardless of scale. It could even be argued that Ness et als "temporal focus" line could be reversed to place prospective (design) at the front end, with retrospective (Post Occupancy Evaluation and building operation) as the onward path.

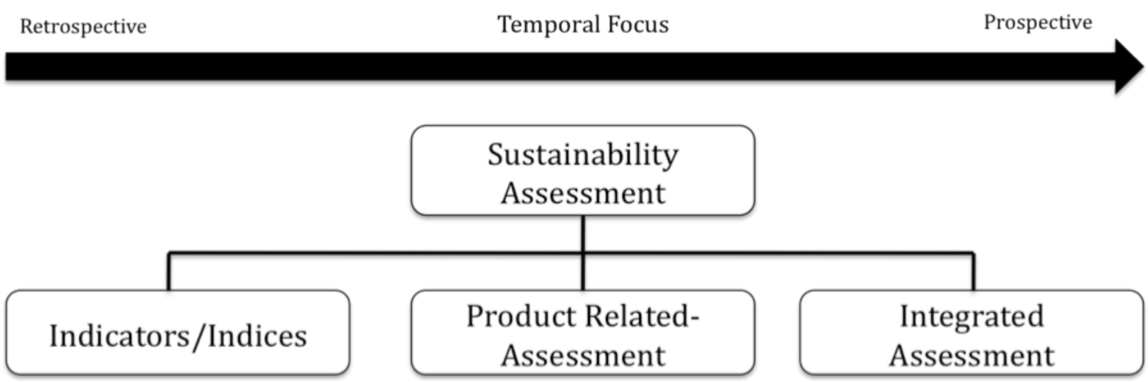


Fig 2.6.2. Sustainability Assessment Framework framed within a progressive time-line. (Adapted from Ness et al 2006 pp. 500)

The temporal focus, or timeline, as presented in Figure 2.6.2 should be considered against the 'level of intervention' model illustrated earlier in Figure 2.3.2. In an effort to establish commonality between aspects of sustainability measurement, sustainability assessment, the construction and refurbishment process, and ultimately the decision making process, the linear continuation of time is the only true unavoidable and mandatory constant. This can of course be expanded in far greater detail, especially in regard to the cost and life cycle implications associated with the planning, design, and construction process. At present however, the review will take the wider approach in establishing context and linkages. A further commonality, which becomes apparent within the 'model development' chapter, is that the timeline is the constant and ever present 'rule' that over-arches, and to an extent, defines, the decision making process itself.

2.6.3 The International Context

Given the sheer number of assessment methodologies, it is important for chapter credibility (and to lay a discussion foundation) to review the models on an international scale in the first instance. The number of international sustainability assessment methodologies is (as mentioned above) very extensive, and these in turn may be found within measurement frameworks of the models themselves. Singh et al (2008) identify three of the highest level frameworks used as the basis for measurement at international level, as The World Business Council for Sustainable Development (WBCSD, 1997), the Global Reporting Initiative (GRI, 2002 a, b), and the Organisation for Economic Co-operation and Developments, development of standards (OECD 2002, a, b) In visualizing the connection of these frameworks to the well known tri-partite model of sustainability, Figure 2.6.3 shows the hierarchical structure of one of the main high level systems (GRI) to demonstrate how the component parts of the model are streamed.

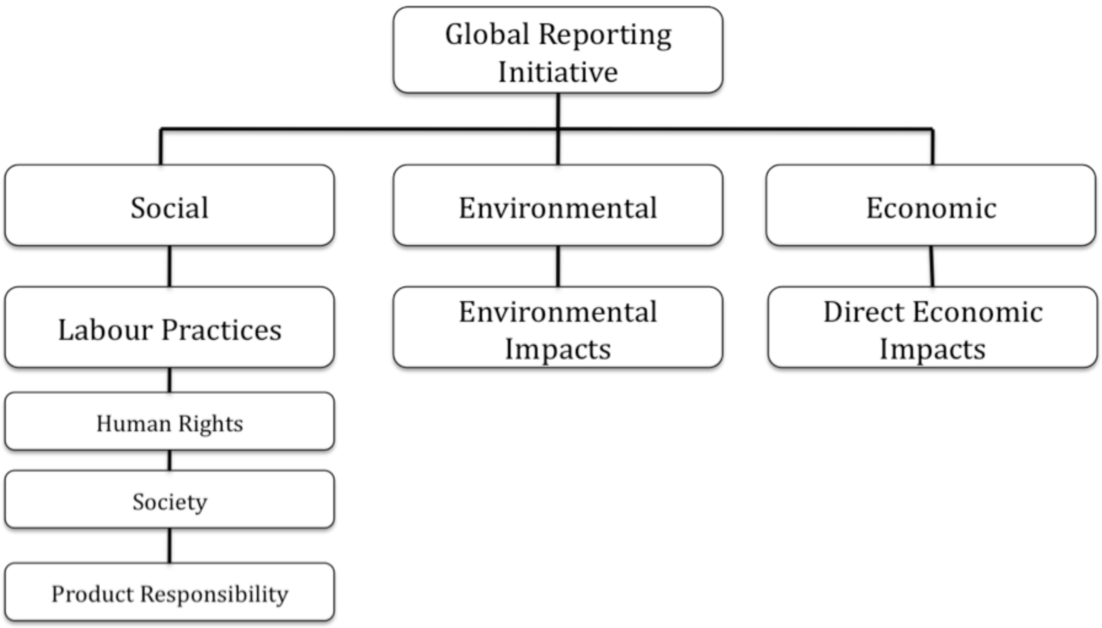


Fig 2.6.3. Summary framework of the Global reporting Initiative (GRI) showing the relationship to the tri-partite Social, Environmental, and Economic sustainability model of Sustainable Development. (Adapted from Singh et al. 2008 pp. 193)

It is significant to note at this level of framework, that there is as yet, no real discernible push, from any of the systems at integration. This is an interesting point, as the indicators below the main 3 component parts of Social, Environmental, and Economic (Table 2.6.3) begin to separate into clearly assigned areas or sectors which, it will be seen, possess a hierarchy of their own, demanding assessment methodologies and tools which are 'forced' towards integration to be deemed successful, effective, or perhaps even credible. In respect of the requirements of the research process itself, the issue of integration is highlighted by Kates et al (2001) who frame questions asking how the operational, reporting, planning, and monitoring systems can indeed be integrated into effective and adaptive systems. This issue of integration may be perceived as the fundamental measure of success to any sustainability assessment methodology or tool, regardless of subject matter or scale, and referring back to the initial, 'basics' of the literature reviews discussion, this is clearly supported through the physical representation of the integrated sustainability model.

Core Sustainable Development Indicators		
Social	Environmental	Economic
Sub-Indicators within the Tri-partite Sustainability Model		
Equity Health Education Housing Security Population	Atmosphere Land Oceans, Seas, Coasts Fresh Water Biodiversity	Economic Structure Consumption Production

Table 2.6.3. Demonstrates the relationship between the core sustainability indicators as understood within the well-known sustainability model, and the subsequent requirement to group and quantify specific sustainability issues or areas. Although necessary as a basis for structuring the management of specific issues, a seemingly unavoidable consequence is the move away from integration.

In this context, Table 2.6.3 presents examples of clearly defined areas to be considered within the wider frameworks, yet these may be viewed as the 'main ingredient' of the whole sustainability assessment process when they are considered in terms of being sustainability 'indicators'.

2.6.4 The Importance of Indicators

Understanding the purpose and the reasoning behind the indicators is crucial to grasping the sustainability assessment process and the integration opportunities within the indicators themselves. The indicators provide both the parameters to each individual issue, and as recognized by Lancker and Nijkamp (2002), they provide a reference point from which can be derived 'thresholds'. Given the earlier discussion on the temporal line of the over-arching sustainability assessment process, thresholds (or targets) are essential management functions to allow for performance aspiration, and performance monitoring. This is absolutely fundamental to the management function, in that to manage an issue, or range of issues, the ability must first be created to 'measure'. This will be clearly highlighted and explained in Chapter 6, and the measurement and quantifying of criterion inputs, will be demonstrated as crucial. Therefore, the importance of identifying indicators is closely aligned with the identification of key criteria for the eventual decision making process, and in this context, the review begins to thread together the relationship between sustainability assessment models and the decision making models themselves.

The issue of measurement is a critical point that demands greater clarification in regards to the actual measurement systems employed. More correctly perhaps, the 'measurement systems' may be referred to as the 'metrics'. Singh et al (2008) highlight the need to separate the purpose or function of the metrics, from the concepts and tools. The point is made that the metrics are means to define and give shape to frameworks, and not to provide actual real time work within sustainability assessment and development. The example provided by Singh et al (2008) is the use of metrics as feedback loops for the process. Drawing back to consider this approach in regard to the design process within a construction or refurbishment project, this iterative approach mirrors the methodologies and thought processes employed by the design team and during design development. It is also proposed that this process is absolutely fundamental to the decision making activity itself and therefore, of great importance to the prototypes development.

An overview of the *meaning* and *purpose* of sustainability 'indicators' has been discussed, yet when considering sustainability assessment at its highest or international level, it would be remiss not to also review the construction of sustainability 'indices'. There are an almost bewildering number of sustainability related indices in use across the world, each specifically designed to address a certain issue, or set of issues, within the wider sustainability agenda. As the collective noun implies, the indices represent the aggregation of the index, which is essentially, a list of the chosen sustainability indicators to address a particular area. These indices are relevant to the particular sector or organisation employing them, such as the banking sector, the oil industry, the construction industry et al. Although, as discussed above, there are a significant number of these indices, Singh et al (2008) identify 12 main indices 'groups', consisting of:

1. Innovation, Knowledge and Technology indices
2. Development Indices
3. Market and Economy Based Indices
4. Eco-System Based Indices
5. Composite Sustainability Performance Indices for Industries
6. Investment, Ratings and Asset Management Indices
7. Product Based Sustainability Index
8. Sustainability Indices for Cities
9. Environmental Indices for Policies, Nations and Regions
10. Environment Indices for Industries
11. Energy Based Indices
12. Social and Quality of Life Based Indices

In all cases, the indicators (as described earlier) contained within the different sustainability indices must be considered against the input-output requirements or expectations. Returning to the earlier definition of the sustainability metrics, the indicators themselves must be constructed within a set of logical rules, which allow for computation and analysis on a level playing field. Where such a playing field does not exist, the indicators must be scaled, aggregated, or weighted to present common rules or algorithms, which will present meaningful data. It is argued that this in fact may be one of the most challenging aspects of creating a sustainability assessment methodology or tool at any level, as in the first instance, there is a justified risk that subjectivity may taint the validity of the metrics or analysis systems used. Interestingly, it could just as reasonably be argued that given the specific design and nature of a particular tool or methodology to a particular user group or subject area, a subjective or 'intuitive' approach is essential to address the unique factors associated within a given context. The second significant challenge is considered against the earlier discussion on Ness et als (2006) sustainability framework in regard to its inclusion of a temporal focus. There is of course, no doubt that a time-line exists and the framework has been created in tandem with this along a logical line of thinking. However, there is scarce mention in the literature of the fact that although a sustainability indicator may be created, a given circumstance in a given community, company, or project will change through the passage of time, thus rendering the indicator, or aspects of it, obsolete or non-representative.

This last point has the capacity to be incredibly complex and challenging, and to ignore the fact that 'things do change', and to have no built in evolutionary capability to the indicators or tools, may ultimately result in skewed or inaccurate data. The answer, or best attempt at a solution, may lie within the field of probability and statistical calculation. This issue especially will lead into the realm of decision making tools and multi-criteria analysis.

2.6.5 The Connection with the Built Environment

In considering the extensive range of environmental and sustainability assessment models for the built environment, there is a temptation to begin by listing each and every method used in different countries, and to begin to make comparisons of usage, effectiveness, ease of use etc. However, the previous section has shown that before exploring the benefits or disadvantages of a specific tool or method, it is first essential to summarise a basic understanding of what the purpose and/or function of the tools actually are. This can be expanded to consider the common drivers for usage at all. As with the challenge of the identification and subsequent analysis of a chosen sustainability 'indicator set' on the higher level models and indices, it seems unavoidable not to shape a tools variables within the influence of such areas as geography, cultural influences, or even the national economic situation. Once again; early threads are appearing on the potential model development in recognising from the outset that the healthcare systems and the capital investment rules applicable to it, will demand a tailored and inclusive approach.

It is informative to appreciate that the evolution of sustainability assessment tools for buildings, stem mainly from the issue of energy usage and consumption. Chew and Das (2007) identify the 1990s as the decade where owners and facilities managers began to become increasingly concerned with the rising costs associated with energy usage and maintenance. This is interesting in the fact that although inherently related, the issue of emissions reduction did not seem to factor as the first and main driver to assess energy usage. Chew and Das (2007) do however, make the point, that a sustainability assessment model should consider a far wider set of parameters, inclusive of life-cycle methodology, covering the whole building process from design, through construction, operation, and a facilities maintenance. Using the cradle to grave philosophy, this could be expanded to include the structures end of life and subsequent re-use or recycling.

2.6.6 Differences in Classification

In an attempt to classify sustainability assessment tools, Trusty (2000) suggested a 3 level breakdown, which competently captures the fundamental differences in philosophical approach, before the point of specific tool identification. These have been presented in summary format in Table 2.6.6, but essentially identify and separate product comparison tools, building design and decision support tools, and the whole building assessment methodology. This approach supports Liu et als (2006) classification of tools 'functionality' which identifies the 4 main 'evaluation systems' as (1) Educational tools (2) Performance assessment (3) Decision making support and (4) Decision making assessment.

Level	Tool Type	Notes
1	Product Comparison	Database and catalogue for Life Cycle assessment (e.g. Green Guide to Specification)
2	Whole Building Design/Decision	May be 'active' or 'passive' in nature. E.g. Integrated Design Process (IDP) for passive, and Standard Assessment Procedure (SAP) for active
3	Whole Building Assessment	Holistic assessment frameworks or systems such as LEED, or BREEAM

Table 2.6.6. Based on Trustys classification process (2000), this demonstrates the separation of the main sustainability objectives into hierarchal categories.

What Table 2.6.6 shows, is that as the category level increases from 1 to 3, the complexity and integrative opportunities become more apparent. Given the various categories included within both the LEED and the BREEAM processes used as examples in the Table, it may also be identified that both level 1 and 2 are in fact incorporated within the Whole Building Assessment classification. This is a key point in exploring integrated solutions and methodologies.

In regards to the levels described in Table 2.6.6, the ongoing focus of the review is primarily targeted on reviewing sustainability assessment models which lie within the level 3 category of Trustys classification process. As stated above, this should capture the level 1 and level 2 systems by default, although this raises the issue of indicators and subjectivity yet again, as it is by no means a given that all of the level 3 tools are entirely similar. This is evident not only in the selection of categories themselves (such as management, energy, materials, transport, water consumption et al) but also within the *grading criteria*. This echoes the same challenges identified earlier, regarding the absence of a level playing field or set of common denominators between systems. Chew and Das (2007) acknowledge this especially in respect of the grading criteria and methodologies employed (scoring, weighting, benchmarking) Reinforcing earlier comments, clear and logical links are appearing in relation to the requirements for the prototypes design.

2.6.7 Generational Models

In continuation of the theme of differentiation between the differing types of level 3 tools, Todd et al (2001) separated the various systems into *generational* categories. Although this categorization does not necessarily address the differences in commonality between systems, it does however place them into descriptive parameters, which inform the observer or user of the grading criteria, employed. This in turn gives a quick appreciation of the level of complexity within a given system, although also arguably, the level of detail and accuracy of the categories or indicator sets.

In the most basic of terms, these generational classifications are given as:

- First generation: Simple 'pass-fail' systems
- Second generation: Score additive
- Third generation: Weighted additive
- Others

For the purposes of the model development, and the framing of the main objectives and research questions, the first generation 'pass-fail' tools are not reviewed in great detail. It is recognised from the outset, that the complexity and high number if variables associated with the hospital refurbishment process and its modeling, demand a more comprehensive approach.

Given that the first generation systems have been discounted, the decision must be made as to selection of a second and third generation system, and also a system encompassed within the term 'others'. A 2008 discussion document published by the Building Research Institute (BRE 2008) identified an approximate number of international sustainability models at around 600 different systems. Clearly, it is not feasible to address each of these, nor even a significant percentage. On this basis, the review has identified tools that are in the first instance, concerned specifically with the built environment, but also systems that present a reasonable geographical spread throughout the western world, and finally, tools that are the most prevalent and understood within the international construction industry.

The selected tools are shown in Table 2.6.7, alongside the country of origin and year of development of the systems themselves. It should be noted however, that (certainly in the case of LEED and BREEAM) these systems have an international component and are used in various countries across the world (this includes the use of both systems within the same country)

Tool Classification	Tool Name	Country of Origin	Year of Development
2nd Generation	Leadership In Energy and Environmental Design (LEED)	USA	2000
3rd Generation	Building Research Establishment Environmental assessment Method (BREEAM)	UK	1990
Others category	Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)	Japan	2004

Table 2.6.7. Selected international sustainability assessment models related to the Built Environment.

The tools selected offer a good platform for comparison (where possible) and review for the same reasons given above in regard to geographical spread and generational categorization. This is a fundamental aspect of the intention of the literature review, and also of the relationships or disparities between the tools themselves. Reed et al (2009) illustrate this point very clearly in their comments that whereas a notional office building could very easily be compared with its international cousins in regard to value, (the example they use being the use of a 10 year discounted cash flow approach, allowing for variations in exchange rate), if such a comparison on the same buildings is carried out in regard to sustainability performance or assessment, the exercise would be far more complex. If it is considered that aside from purely geographical differences, the rating systems and metrics criteria may be different in regards to a single issue, then the challenge becomes even more complex. The issue of multi criteria selection is beginning to emerge as not merely a preferable approach to a decision-making or management system, but as an essential approach.

2.6.8 Challenges in Comparison

The literature indicates that there appears to be two main areas for discussion in attempting to compare the selected assessment tools. The first issue is the choice of indicators themselves, as these are not replicated across the tools concerned. There is in fact, no known single tool or system which addresses all of the main sustainability criteria commonly understood across the spectrum. An example of a criteria indicator that is not covered by any of the tools chosen within this section is 'economy'. To demonstrate this point and highlight the variability between tool criteria, economy is covered by the German *DGNB-Seal*, the North American *Green Globes*, and the Italian *Protocol ITACA* (REED et al 2009) The second area referred to is in the area of rating calculation and associated weightings of credit criteria. Granted, for a more meaningful comparison on weighting systems, it would be more advisable to compare tools from the same generational group, as this is the basis for classification, yet given the actual spread of use of the tools (especially LEED and BREEAM), it is still nevertheless informative to review and compare the methods involved. (Table 2.6.8)

Tool	Ratings	Weightings
LEED	• Certified • Silver • Gold • Platinum	Equally weighted credits throughout
BREEAM	• Pass • Good • Very Good • Excellent • Outstanding	Applied differently to each issue/category based on consultation
CASBEE	• C • B- • B+ • A • S	Weighting system is highly complex at every level

Table 2.6.8. Basic comparison of selected assessment tools

2.6.9 The New Build versus Refurbishment Question

Consideration and comparison of new-build projects against refurbishment projects is a key point with which to highlight another fundamental difference in the capability of various assessment tools. This relates specifically to the built environment, and concerns the very different processes and project parameters and scope between a new-build structure, and the refurbishment of an existing structure. There seems little doubt, that given the required degree of will, and a realistic budget from the Client, a new-build project has the capacity to be shaped to the optimum performance rating from the early appraisal and design stages. It is fairly well understood nowadays, that as noted by Ding (2007), any form of environmental assessment tool or methodology has the greatest potential during the design stage, where a robust design and discussion process can identify opportunities and clashes respectively.

As has been discussed in the earlier sections of the review, refurbishment is arguably far more complicated and fraught with risk than the new build process. Notwithstanding the technical unknowns, and what many previous researchers have referred to as the 'inherent uncertainty of the works themselves' (Egbu and Lee 2006) (Azlan-Shah 2010) (Quah 1988) (Aho et al 1998), it is reiterated that the design process may be hindered from the outset by the reluctance of the designers to commit and engage fully with a process which may result in unavoidable mistakes due to lack of information (Beyond 1990) However, the issue of refurbishment is addressed by some of the more commonly used tools, especially in the context of this study, by both LEED and BREEAM. There are obvious and immediate limitations placed upon the environmental assessment of a refurbishment project, such as limitations in location and orientation. To use BREEAM as an example, the location of a building will have either positive or negative consequences on the Transport credits, due to accessibility to a public transport network. Similarly, within the Health & Wellbeing section, daylight calculations and 'view out' credits, may be limited by existing footprint or layouts. Ding (2007) highlights this point with the observation that the practical difficulty or expense involved in the replacement of an existing ventilation system or glazing configuration may be prohibitive. These two examples are quite telling, in the sense that ventilation and lighting/daylighting are two heavily weighted components in most sustainability assessment scoring mechanisms. This opens the discussion to begin considering a decision-making solution, which is flexible enough to consider the built asset as a unique entity, but the flexibility also, to allow the decision-makers themselves, room to maneuver in selecting and ranking their own identified criteria and options.

2.6.10 Integration with the NHS

This review is intended to form the basis for the wider research objective to consider specifically, the refurbishment of hospitals. To this end, it is recognized that, despite the various tools and methodologies available to the NHS as the Client, there is another factor which limits or directs (depending upon a particular point of view) the range of choices and mechanisms available to carry out environmental and sustainability assessments. This is the issue of legislation and policy.

The NHS (from a United Kingdom perspective) is a publicly funded institution, and therefore is subject to the requirements for capital projects, which form part of the government estate. The key issue here is that it is a mandatory requirement to use the BREEAM methodology for both new-build projects and refurbishment projects within the NHS. In addition to this, and in common with other publicly funded institutional buildings, a funding requirement for capital investment within a new build project is the achievement of an 'excellent' rating from the BREEAM tool. In England and Scotland, there is the additional requirement for all refurbishment projects over the value of £2million to achieve a 'Very Good' rating. (BRE Online 2011) It is interesting to note that although the BREEAM Tool is the over-arching assessment method for the construction or refurbishment of the hospital, there are additional 'stand alone' tools which, although tools within their own right, have direct tie ins to the achievement of BREEAM credits. Examples of this are the *Achieving Excellence Design Evaluation Toolkit* (AEDET Online 2011), which focuses on the consultation credits by engaging staff through a series of non-technical questions to address the main areas of impact, build quality, and functionality. In addition to this, and remaining in the area consultation, but within the Management section of the BREEAM assessment, the *Good*

Corporate Citizen (Online 2011) model seeks to engage the senior managers and decision makers in placing sustainable considerations at the heart of any decision making process. What is significant about the structure and included aspects described above is that by default, high level 'mandatory' criterion selection options are emerging. Yet again, this is beginning to provide shape and boundaries to early consideration of the model development, especially in the context of refurbishment.

2.6.11 The NHS Challenge

Retaining the focus on the refurbishment of the hospital, the review has so far identified areas which may be detrimental to the actual achievement of sustainability performance, but at the same time, may offer the opportunity for monitoring and recording the positive effects of a sustainable approach on a collective, or national level, rather than focusing on a particular refurbishment project in isolation. To explain this point further, it is instructive to revisit the £2m threshold for a BREEAM assessment on a hospital refurbishment project. In the first instance, there can be no guarantee that a higher value (and therefore qualifying) projects scope, may not be broken down into smaller value 'stand alone' work packages (below the £2m threshold) to circumnavigate the requirement for an assessment. Granted, the NHS Capital Investment Guidance does require a pre-assessment to be undertaken and sustainability possibilities evaluated on all projects regardless of value, yet there is every possibility that in many cases the Design Team and Contractor may enter the process with the aspiration to fail, rather than to succeed. Given the restrictions in budget they may face, this is perversely a wholly understandable approach in practical terms in aspiring to achieve project success. One of the observations highlighted by this research to date however, is that given the continual nature of refurbishment work across the NHS Estate, the *collective* impact of improved sustainability performance (especially against the background of energy and emissions reduction targets) provides an opportunity which may not be only desirable, but essential. The requirement for a formalised and measured process seems to be clear in this context.

2.7 Reviewing Environmental Management Systems

The literature supports the case, that Environmental Management Systems (EMS) have become increasingly more prominent in the last twenty years. Modeled on the success of the earlier *ISO 9000* standard (focusing primarily on the 'quality assurance' aspect), the most dominant EMS in use today is the *ISO 14001* standard. There are a number of perceived benefits of EMS implementation, yet the voluntary and self-authored nature of the system may also question the effectiveness or even credibility of the standards function. The EMS is found to be well suited to integration with existing management systems, such as *ISO 9000*, yet a random sampling of published guidance and literature highlights an almost complete omission of references to any form of EMS in the NHS. *EN 16001: European Standard for Energy Management Systems* is identified as being closely aligned with *ISO 14001* which would allow easy integration between the two systems. This is presented as especially significant in regard to the requirements set out in both the *Carbon Reduction Commitment Energy Efficiency Scheme* and the *Climate Change Act 2008.*

The relationship to the main objectives of the research, and the models development, focuses largely on the fact that both the NHS as a Client, and the Design Teams ands Contractors undertaking the planning, and implementation of the refurbishment works themselves, are very likely to operate within the parameters of a corporate Environmental Management System. When considered within the decision making process, this may have significant input to the issue of specification of certain materials and also the conduct of the work practices themselves. Therefore, and to demonstrate rigour and diligence of review, the EMS must be reviewed in the context of being embedded as a core component within any sustainability focused decision-making process. Additionally, the EMS (as part of the wider review) ties into the previous section which discussing the sustainability management systems, most notably for the NHS in the UK, the BREEAM Assessment.

2.7.1 History of the EMS

It has been highlighted that the issue of Environmental Management Systems (EMS) has become more prominent over the last 20 to 25 years. This has been doubtless driven (in part) by the emergence of the environmental movement generally, and the exponential growth in awareness of the issue of sustainability. In 'purely' management terms, outside of sustainability or environmental considerations, it may be proposed with some confidence that many, if not most, organisatons related to business or commercial operations, adopt a systematic approach to the area of management. It is instructive to build upon the basis of 'standard' management systems to understand and review the evolution and effectiveness of the more specialized management systems such as ISO 14001.

The *management concept* then, is by no means new, although it has become inordinately more refined and complicated in regard to the passage of time and the accumulation of experience. Perhaps the first alleged examples of *project management* techniques, can be attributed to the construction of the massive Egyptian pyramids, or the Great Wall of China (Burke 2006), and in more recent times, the appearance of the Gannt chart. In the UK, and born out of the shipbuilding industry in the First World War. The Gannt chart is considered by many to have changed the process of management (and history) forever. As a forecasting and monitoring tool, this system is still widely used in the 21st century.

Project management as a discipline came into its own through developments and adoption by the US Defence Industry, and by NASA in the late 1950s and the 1960s (Burke pp.16)

Although seemingly loosely related to the aims and objectives of the model development, this chronology is actually quite significant, as one of the first real *quality standards* is recognised as being utilized by the US military and aerospace programme (also in the 1960s) (Sumner & Thorpe 2004) The other *major* standard at this time was to be found in the UK in the shape of the *05 Standards* which evolved firstly, into the *BS 5179,* and then in the late 1970s, into *BS 5750*. In 1987, the *International Standards Organisation*

(ISO) adopted BS 5750 as the basis for the first internationally recognised quality standard. BS 5750 was subsequently adopted by ISO as the platform (virtually unchanged) for the production of the ISO 9000 series in 1988. The ISO 9000 series is now widely recognized as the international benchmark for quality assurance across a wide diversity of industries.

How is this relevant to Environmental Management Systems?

Environmental Management Systems were a later arrival to the management suite of tools than the quality standards. Similarly though, the first recognizable EMS came as a British Standard in the form of *BS 7750: Specification for Environmental Management Systems*. (Environmental Management Systems, Online) BS 7750 provided the foundation for the creation of the *ISO 14001 Environmental Management Systems*, which has been largely adopted, along with the alternative *Eco-Management and Audit Scheme* (EMAS), as European standards for environmental management.

Given that the systematic approach taken by the ISO 14001 standard (which itself is aligned very closely with the EMAS model) mirrors in many ways the ISO 9000 model, the development of the EMS can be viewed as a development of this existing system. On this point, it has been suggested that it was the measure of success for the ISO 9001 standard, which acted to a large degree, as the catalyst to develop the EMS along similar lines (Miles and Russell 1997. Corbett and Kirsch 2001)

2.7.2 Defining the EMS

The foundation has been has been provided, to understand the history, and the inextricably linked 'methodology' of an over-arching management system. In reviewing the EMS in greater detail, it is proposed that this level of 'base-knowledge' is critical to provide context to the review going forward. The EMS therefore, can now be focused upon and defined in specific detail. This will in turn, feed into the surfacing discussion in regards to the requirements for designing and constructing the decision support prototype.

An EMS is defined by ISO as:

"Part of an organisations management system used to develop and implement its environmental policy and manage its interaction(s) with the environment" (Online ISO/DIS)

The *Institute of Environmental Management and Assessment* (IEMA) is slightly more succinct in explaining an EMS as…

"…a structured framework for managing an organizations significant environmental impacts" (IEMA Online)

The important factor to note from the outset is evidenced in the name itself, in understanding that the EMS is a 'system', and therefore seeks to employ a systematic approach to its implementation. To achieve this, O'Doherty (1998) presented the four basic elements required for any EMS, regardless of the finer detail:

1. Environmental policy development
2. Environmental effects and their evaluation
3. The setting of objectives and goals for improvement
4. Continued compliance through system auditing

These four main elements are informative in presenting the basic framework required for a complete EMS, yet there is no clear reference to a methodology of how the system should be implemented and operated. Regardless of whether a standard is developed at national, European, or even international level, the methodology common to all EMSs is presented in the form of the *Deming Cycle*.

The creation of the cycle is credited to W. Edwards Deming in the 1950s, as a means whereby deviations from client requirements could be analysed and measured to ascertain the source of any variation. (Balanced Scorecard Institute)

The model is constructed to allow a continuous loop, which allows intervention and amendment (improvement) at any point in the cycle with the ultimate goal of *continual improvement.* As will be demonstrated within the later discussion regarding the structure of the EMS, the issue of continual improvement is a keystone element to the whole system. Lessons are taken from this structure in regards to the models development, as by the nature of the design process, the 'loops' referred to in the context of the Deming Cycle, replicate (to a degree), the iterative nature of the design, and therefore, decision-making process.
It can be seen in the simplified diagram presented in Figure 2.7.2 that the loop elements of the model consist of the requirement to:

- Plan
- Do
- Check
- Act

The *Plan* aspect, allows for design or revision of a business or system process to improve results. *Do* is self explanatory in its direction to implement and measure any of the potential revisions. The *Check* is an assessment process of the measurements taken, followed by any reporting requirements to those with authority for decision making, and the *Act* aspect is the decision making process and outcomes to improve the process where necessary.

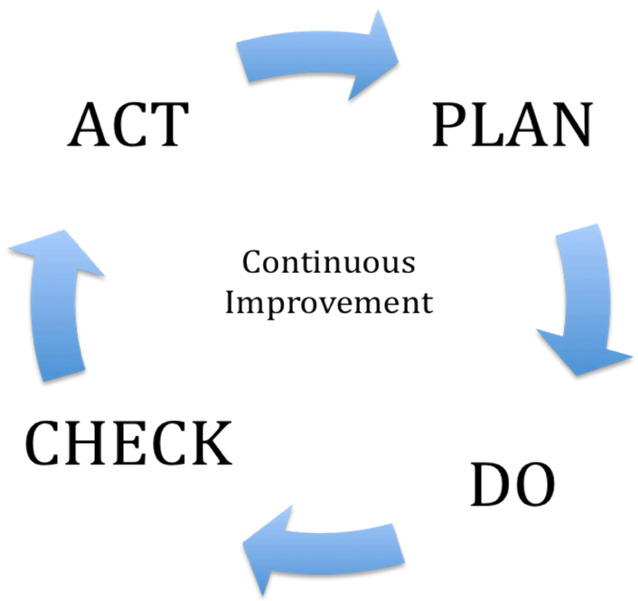


Figure 2.7.2: The Deming Cycle

2.7.3 The Prominent Management Systems

It would be difficult to argue against the fact, that the most commonly utilised EMS in the world today is the ISO 14001 standard. ISOs own survey conducted in 2008 (ISO 2008) measured the number of awarded certificates by the end of 2007 as being in excess of 154,000. This figure spreading across a range of 140+ countries. The only other scheme of a significant scale is the EMAS model which, again measured from the end of 2007 accounted for in excess of 7600 physical sites operated by circa 4400 organisations (European Commission 2010)

It should be understood that the differences between the ISO 14001 and EMAS are not significant. What EMAS requires that ISO 14001 does not, is that the certified organisation publishes an environmental statement that has been independently validated, with the purpose of bringing public attention to any significant ecological or environmental factors. The motive driving this additional step is to move beyond mere compliance and recognize best practice with the reward of enhanced credibility and recognition. (IEMA Online)

With this in mind, it is deemed sufficient to explore the main characteristics of the ISO 14001 standard to identify the main components of a robust EMS.

In relation to the earlier recognized elements of a generic EMS (O'Doherty 1998), the ISO 14001 standard builds on these core elements in requiring 5 principles to be addressed. Each of these principles address the numerous sub-elements required for the detail of the system (Figure 2.7.3), but are listed at the higher level as being:

1. Environmental Policy
2. Planning process
3. Implementation and operation
4. System checking and corrective actions
5. Management review and continual improvement

It is important to clarify at this stage that the standard is by no means prescriptive, and as stated by Hesan et al (2001), the purpose is to 'compliment' any existing national regulatory regime and not to duplicate or replace.

In continuation of the issue of the standards relationship to regulation, it is reiterated that the EMS standard under ISO 14001 is a *process* and is not intended to be a *performance* standard. This is a key point in understanding the capabilities and parameters of the system which, may in turn, open a debate on the actual effectiveness of a system which is voluntary and self imposed by nature. Melnyk et al (2003) capture this well in identifying that the standard does not mandate the optimum environmental performance for an organisation, but presents a system whereby the organisation in question is guided in achieving its own environmental objectives.

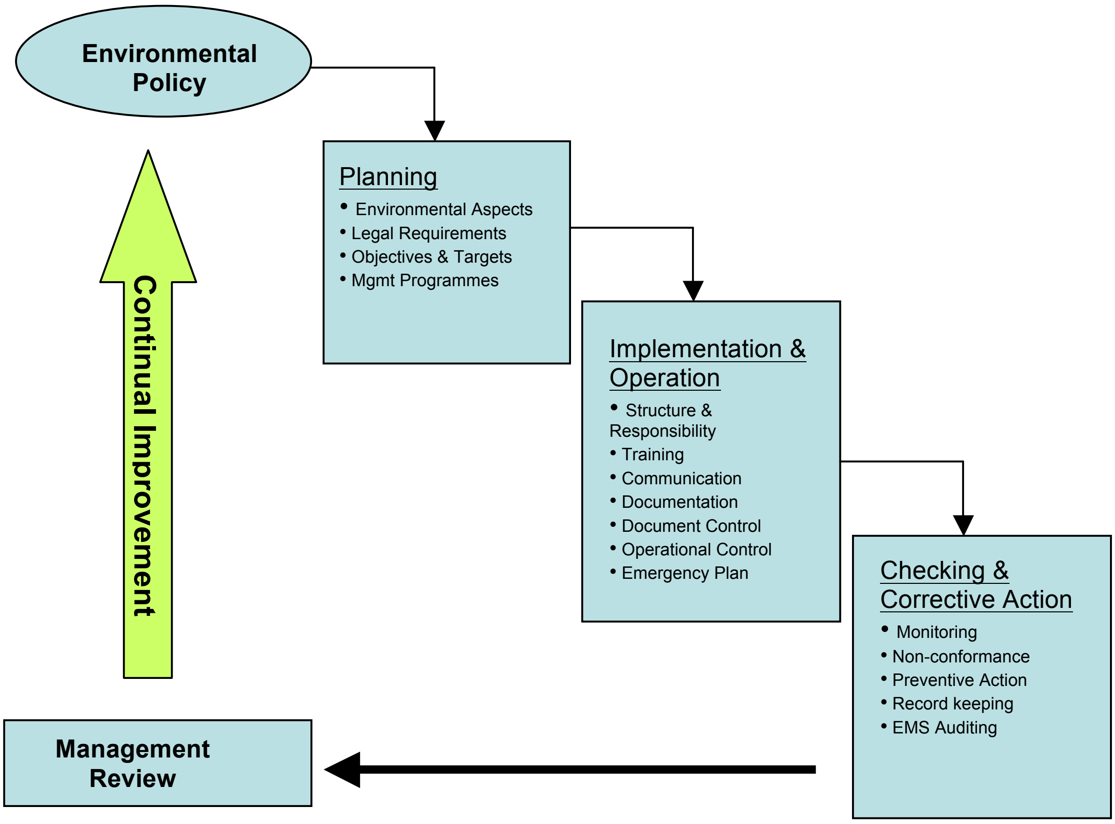


Figure 2.7.3: ISO 14001 EMS Model (Adapted from Hesan et al. pp. 527)

There is a mirroring of purpose in reviewing the EMS as presented and described in Figure 2.7.3, as the earlier review on the sustainability assessment systems. This purpose is largely identified as providing context and early recognition of the requirement to understand and develop main criteria for the decision-making process in regards to refurbishment of the hospital (or healthcare estate). What Figure 2.7.3 also introduces to the conceptual development of the decision support prototype, is the requirement to identify and select a required 'option' that satisfies the requirements *specific to the facility in question*. This may not be immediately apparent, yet the management requirements illustrated must, ultimately, be transformed into tangible decision outcomes. The research questions, in this setting, are beginning to form, albeit in slightly abstract terms.

2.7.4 Other EMS Models

Despite the fact, as observed by Kimitaka (2009) that the ISO 14001 standard is the most widely recognized EMS certification scheme in the world, there nevertheless exist a wide array of EMS models which are in use. This is especially notable in the area of SME's (Inaki & German 2010) whom may not necessarily have reasonable access to the often-significant input of resources required to achieve full ISO 14001 accreditation.

The challenge faced by the SME's in this regard, was noted by Kahlenborn (2004) as being a key driver in the emergence of a 'great diversity' of alternative models for environmental management (AMEMs) It seems beyond doubt that the systems of ISO 14001 and EMAS (in a European context) are the most prevalent systems in use across all industries, and yet it is appropriate to briefly tabulate (Table 2.7.4) a brief overview of some of the main AMEMs still in use today.

NAME	Acorn method / BS 8555	Iniciatava e+5	The Ecoaction 21 Certification and Registration Scheme	Eco-Lighthouse Programme	Ecomapping	Ecoprofit Internationa l
BODY	British Government	Fundacion Entorno	Japanese Ministry of the Environmen t	Norwegian Ministry of the Environmen t	Heinz-Werner Engel and the Eco-Council Institute	City of Graz and Graz University of Technology
FORMATION DATE	2003	1999	1996	1996	1997	1991

Table 2.7.4 : Main AMEMs in use by SME's

2.7.5 Benefits of an EMS

The essential mechanics and components required for an EMS have been discussed, but an essential question requiring more detailed consideration, is the fundamental query of '*why'* should an organisation choose to adopt, what is after all, a voluntary standard. This question is framed against the financial and time commitments required in achieving certification. It is proposed also, that the issue of *why*, although informative, does not go quite far enough in understanding the *motivation* for an organisation to seek certification. On the face of it, the differences of enquiry may seem subtle, and yet the literature review highlights the differences between the two (main) overall drivers. The questions posed should also be considered in the context of the developing research questions in regard to the developing model, as institutionally, or from an organizational standpoint, many of the drivers are the same or similar.

Why would an organisation implement an EMS?

In the private sector, a key factor is to attain competitive advantage in the marketplace. Regardless of any companies 'green credentials' and claims, the purpose of a private sector company is to maximize its profits and returns (where relevant) to its stakeholders. The public sector (of which, in the UK at least and for the present, the NHS is part of) has similar motivations in the commercial sense, although rather than pressured by image or reputation, there are perhaps more politically motivated and reduction in capital spending reasons.

Before ISO 14001 became established as a serious management system, it was found by Melnyk (2003), that there was practically no recognition of the relationship of environmental and corporate performance, either in industry or academia. Such a widely 'accepted' view that a sound business strategy was in direct conflict with the 'requirements' to pursue environmental objectives is a very telling point. Without deeper investigation, it would seem, company investment in the improvement of financial performance would come at a cost, which had no mechanism of return. The question begins to arise on how this return, or measure of success, can be measured and recorded.

This deeply entrenched mindset was challenged in the most simplistic of terms in Porters 1991 paper *Americas Greening Strategy* (Porter 1991), in which it was demonstrated that the pursuit of profitability and the reduction of pollution (which he identified as a key industrial factor for implementing an EMS) were by no means exclusive of each other and on the contrary, were in fact symbiotic in nature. Pollution, he contended, was after all nothing but waste, and waste 'regardless of its source' is a key indicator of inefficiency in product or process.

This can be viewed as a pivotal moment in the growth and credibility associated with an EMS. With arguably the greatest corporate driver as its fulcrum (the bottom line), the environmental agenda moved from the lone voices and activists, to the boardroom.

Although 'waste' is identified as perhaps the first key driver in kick starting the corporate agenda for environmental issues, as EMSs have progressed and matured, the benefits of pursuit and implementation have expanded to address all areas of the wider sustainability model. This includes the well known, and much previously discussed, tri-partite relationship model of environment, social, and economic dimensions. It is reiterated at this point, that the environmental dimension (being the nominal dominant dimension in regards to the EMS in general) is in fact only a single aspect of the three dimensional sustainability model.

Table 2.7.5 presents some of the main drivers for EMS implementation. The point was made earlier that an EMS is adaptable to both public and private sectors, and by the self-authored nature of the implementation process, an organisation has the opportunity to tailor the needs of the system (within the scope of the guiding principles) What Table 2.7.5 also demonstrates, is the recognition of mandatory criteria that must be considered in the context of model development and the decision-making process.

Reduced Costs	• Waste reduction • Energy conservation • Life-cycle Costing
Enhancing Revenue	• Market acceptance of emerging technologies • Packaging and Fair Trade campaigns to attract consumers
Materials Efficiency	• Reuse and recycling • Specification & Procurement
Credibility	• Bids etc.
Horizon Scanning	• Ahead of regulatory curve
Supplier Relationships	• Ability to influence supply chain
Quality	• Total Quality Management relationship
Competitive Edge	• Green credentials • Bids and frameworks pursuit
Risk Management	• Assessment process for risk identification
Reduced Liability	• Avoidance of legal infractions • Addressing long term issues
Social & Health Benefits	• Staff commitment and retention • Positive community impact
Reputational Issues	• Improved media coverage • Maintaining and growing client base

Table 2.7.5: The benefits of implementing an EMS

The ‘benefits’ of an EMS seem fairly clear cut. It is not enough to just accept the benefits of system implementation without some consideration of the weaknesses or problems with this model. The point was made earlier that the EMS is not a regulatory tool, but a voluntary, or complimentary, system (Hesan et al 2001)

This is an important point and is raised against the backdrop of the earlier differentiation between the ‘drivers’ for an EMS, and the ‘motivators’. The observation was made that the differences are perhaps subtle in nature, and yet the effectiveness of the system overall must be considered against the motivators rather than the drivers. This, it is suggested, relies on the fact that the drivers may be viewed as external sources (to a large degree), whereas the motivators are factors driven from *within* the participating organisation. As it is widely understood, that one of the most critical factors for overall system success is the complete support of senior management, it can be argued that the motivational factors and organizations own cultural approach are the real measure of effectives and even credibility to the system.

Hesan et al (2001) identified eight factors for organizational motivation to implement an EMS:

1. Cost savings
2. Top management concern
3. Employee welfare
4. Meeting environmental regulations
5. Meeting customer expectations
6. Concern over trade barriers
7. Following head office environmental practices
8. Gaining competitive advantage

These factors (complimenting the review so far in its entirety) are noticeable in the fact that they are beginning to construct a picture of design team and client (and therefore; decision-makers) high level and implicit criteria.

2.7.6 Criticism of the EMS

It can be seen from Hesans eight suggested points, that much of the content mirrors closely the findings presented in Table 2.7.5. From an organisational point of view however, it may not be enough to simply adopt a 'tick-box' approach, as the there are implementation challenges with the EMS by its *nature*, which have capacity to affect many of Hesans points, and the benefits tabulated in the previous section. This is discussed by Eccleston and Smythe (2002) who reinforce the earlier observations that merely through implementation of an EMS, this provides no guarantee that a particular optimum environmental outcome will follow.

Returning to the issue of senior managerial 'buy-in', the first requirement of implementation is the drafting and release of an Environmental Policy. A clear criticism of this approach is that there is a strong likelihood that an organization will seek to construct the Environmental Policy around the specific business needs of the organization. This was recognized by MacDonald (2005) as preventing focus to be applied to the underlying principles behind any environmental impacts, but focusing instead on a tailor made set of impacts which an organization could set itself up to achieve. This is a key point for debate, as the very credibility of system itself is brought into question. MacDonald continues to assert that there is a danger that some organizations will seek ISO 14001 accreditation (or adoption of an EMS) to secure 'minimal compliance' required. This approach contradicts the very spirit of the systems approach, and yet, by the nature of the business arena, is widely accepted as fact.

The final observation related to the criticism of the EMS is its inadequacy within the area of *contractual issues*. Lam et al (2011) noted this especially in the context of the construction industry, which has arguably one of the most fragmented contractual structures compounded by the phenomenon of sub-contracting. This is an interesting point, as regardless of a projects intention or announcement that it is following sound sustainability principles; this does not always coincide with the actual delivery of the contractors carrying out the works.

An example of this well known throughout the construction industry is the issue of plasterboard. Poor communication and sequencing, or omission of direct inclusion within a tender, often results in plasterboard arriving on site which must be cut to size of the area in question. This has an often vast potential for waste for a material which is now considered as a specialist waste product which must be segregated and disposed of separately. The *real cost* of waste in this instance is potentially enormous.

Simple actions such as the pre-ordering of a set dimension, or indeed consideration of room sizes by the Design team, is an easy issue when caught at the right time. An EMS integrated with a Site Waste Management Plan would effectively design issues such as this out at the earliest stages. This example is reinforced by Poon et al (2004) who recognized the complexity in detail required to align the requirements of a robust EMS with actual sustainable or environmental performance.

Although on the face of it, the discussion on the EMS so far, may not appear immediately relevant to the conceptual and physical development requirements for the model/prototype, it is suggested that this is not the case and the relevance is indeed important. The EMS has been reviewed in terms of high-level implementation, however, what has been demonstrated from reviewing the systems characteristics, is that there is little in the way of a formalised approach that ensures that the best choices have been made. This, it is argued, may be from the higher level i.e. making the decision on what to include within the policy and associated managerial requirements, but also on the more practical level i.e. selecting the correct element or component to satisfy the policy commitments. The issue of plasterboard (given above) illustrates this clearly. The challenges cited, are perhaps in part, influenced by a fragmented and experience based selection and specification process. This is not in itself incorrect; but how does this prove it is the 'best' selection or specification?

This could be expanded in far greater detail, however for the purposes of the review, the value identified is in the early formation of aspects of the future and potential research questions. To ignore an in-depth review of the EMS would, in this context, limit the scope of the evolving research questions, and as many of the requirements found within the system itself can be viewed as key criteria to the sustainability driven decision-making process, inclusion within the review is claimed as sound.

2.7.7 Integration with the NHS

Having explored the evolution, the structure, and the nature of the EMS, the direction of the review must address the integration of the EMS within the NHS.

What is surprising from the outset is the complete lack of reference to ISO 14001 or the actual term 'Environmental Management System' throughout the vast majority of the official published literature and documentation studied for this aspect of the research. The publications selected were selected as a random sample from different bodies and organizations which have been presented in Table 2.7.7.

Although the listed publications are by no means exhaustive, they are however indicative of the avoidance, or even perhaps reluctance, to refer specifically to an Environmental Management System. This may be viewed as fairly unusual, given the nature of the literature and the structure and internationally recognised status of the EMS (especially ISO 14001)

Document Name	Publishing Body
NHS Lothian: Design Quality Framework for Capital Projects	NHS Lothian 2010
NHS England: Marginal Abatement Cost Curve	NHS Sustainable Development Unit 2010
Carbon Footprint of NHS Scotland 1990-2004	NHS Scotland & Health Facilities Scotland
Energy Consumption in Hospitals	Energy Consumption Guide: 72
Health Effects of Climate Change in the UK 2008	Health Protection Agency & Department of Health
The Healthcare Quality Strategy for Scotland	NHS Scotland & The Scottish Government 2010
Hospitals: Healthy Budgets Through Energy Efficiency	Carbon Trust 2010
Health Technical Memorandum 07-02: ENCO2de – Making Energy Work in Healthcare	Carbon Trust & Department of Health 2006
Making Existing Healthcare Facilities Sustainable: Final Report	SHINE 2010
The NIHR Carbon Reduction Guidelines	The National Institute for Health Research 2010
CO2 Reduction potential for NHS England. GHG Emissions 2010-2020 Reduction Measures Update	NHS Sustainable Development Unit 2010
Saving Carbon Improving Health	NHS Sustainable Development Unit 2009
Future Health: Sustainable Places for Health and Wellbeing	CABE 2009

Table 2.7.7: The reviewed publications contained no references to Environmental Management systems.

Although the findings from the selected sample of publications have no reference themselves to any form of EMS, the current structure of the NHS allows that each trust, or Scottish regional equivalent, has the authority and autonomy to set matters in this area for themselves. This perhaps explains the omission in the generic publications, and yet it may be argued that high-level guidance documents could be the first point of direction in regard to EMS implementation. This point is perhaps best considered against the key principle (and essential requirement) of the EMS itself, which is the 'buy-in', and full backing of the Senior Management function.

Regardless of this, another aspect to consider (especially in regard to the PFI process) is that the relevant service provider or consortia with long term responsibility for the hospital may well have EMS's in place of their own. This is more than certainly the case for the major contractors who carry out the design and build aspect of the project, but how this translates into the operational aspect is an area open for further research.

Government guidance can be found for the implementation of Environmental Management Systems within the NHS Trusts through the *Environmental Awareness Scheme for Employees (*EASE Online) which make reference to the requirements set out in the *Control Assurance Standards*, yet the message seems to be surprisingly weak.

The core of the wider research is to look at developing and integrating a sustainability dimension within the refurbishment of hospitals. How this may be relevant (if at all) to the PFI consortia is still an open question. Using England as a case in point, one of the discussed outcomes of the *Health and Social Care Bill* is the consideration of *any willing provider* in providing many of the services to the NHS. Again, given the potential market driven ethos of competing private companies, how will an issue such as the implementation of Environmental Management Systems which align and compliment wider legislative and corporate targets, be approached?

2.7.8 Integration with other Management Systems

It has been noted earlier that there are many similarities between the ISO 9000 standard, and that of ISO 14001 (Miles and Russel 1997. Corbett and Kirsch 2001), and indeed the 14001 standard was in large part a result of ISO 9000s success.

The main 'positive' of this relationship is the possibility of developing an *integrated* management model, which allows 14001 to be merged into the existing quality standard to provide a single system. Clements (1996) demonstrated the affinity of both systems with the analogy that rather than just a cousin system, 14001 was more *sister* system to 9000. The attraction of an integrated system seems to speak for itself, especially if an organization is familiar with the process and structure of one or the other to begin with.

The issue of integrated systems is of especial interest in consideration of the *European Standard for Energy Management Systems – EN 16001*. In relation to the possibilities regarding the NHS, it is informative to know that the 16001 standard was adopted in 2009 as a British Standard. As with the crossovers between 9000 and 14001, 16001 is adaptable as a fully integrated aspect of the wider EMS (BSI Online) Although BSI recognize that the two standards are very closely aligned, the key differences they present are:

- Greater emphasis on energy aspects in regard to the identification and management. This is given to include past, present, and future consumption.
- Greater focus on the energy consumption and the relationship between the way energy is used and other more fundamental factors.
- A requirement to monitor and record 'actual' versus 'predicted' consumption figures.
- Moving beyond the control of operations and addressing prevention.

The summary above may not seem that significant, but if the specifics are considered in relation to the *Carbon Reduction Commitment Energy Efficiency Scheme* (DECC Online) requirements, and additionally within the wider strategic aims of the Climate Change Act (HM Government Online), the benefits of implementation seem self explanatory. Although energy focused, the principle remains the same. The literature and the existence of the various management system types, lean heavily towards the need for integration. These lessons are not lost within the context of the review and the conceptual development of the proposed model. The sustainability assessments, the management systems, and the clear volume of variables, criteria, and potential option selection routes associated with the sustainability focused refurbishment of an asset as complex as a hospital or healthcare facility, clearly signpost the parameters of the proposed model, and the research questions that require answering in order to design and construct it.

2.8 Reviewing Decision Making Models

It can be seen, that throughout the review to this point, one of the key observations has been the sheer scale of the undertaking in regards to the refurbishment of hospitals and healthcare facilities within the requirements of a sustainability driven approach. Assessment methodologies and management systems have been reviewed, which are relevant to the subject area, and yet despite their efficacy on a stand alone, or semi-integrated basis, the drivers, and the very processes themselves have no clear and coherent alignment. If it is 'given', that much of what has been reviewed already may actually be interpreted or accepted as the identification of key criteria, and to an extent, guidance on a high level exploration of potential options, then it is reasonable to suggest that the next phase of the process would be to find a means to consider all of these within a single activity (or model) This leads the review into the field of decision-making (i.e. criteria versus options) The range of decision-making tools and models is vast, and it is accepted that therefore, limitations exist in the range of methods to be presented. However; a key objective at this stage, is not to design or develop a decision-making model per se, but to explore and develop the necessary research questions, which will allow the focus to be retained and maximized on the subject area. To this end, it is critical to understand the principal mechanics of the discipline itself.

2.8.1 Decision Making

As stated above, the issue of decision-making itself must be clearly understood in the first instance. In the context of the wider research, the review is concentrated upon 'formal' decision support techniques which, in the main, are expressed through the creation and employment of models. Bouyssou et al (2000) define the decision and evaluation models (within the context of formal techniques) as:

"A set of explicit and well-defined rules to collect, assess and process information in order to be able to make recommendations in decision and/or evaluation processes"

This definition speaks for itself in introducing the *process* of decision-making, but it is proposed that to understand the motivation for making a decision, is also critical to understanding the structure of the process itself. Loken (2005) makes the valid point that the decision maker is (at the most fundamental level) concerned with attaining what he terms the "optimal solution". What is potentially more interesting is his view that the "true optimal solution" which is the ultimate goal of the decision maker, may only be possible if measured against a single criterion. This single criterion approach is beyond argument in being completely inadequate when faced with technical or financial decision scenarios (especially in the context of an asset as complex as the hospital) In this context, Triantaphllou (2000) highlights the rising dominance of the area of Multi-Criteria Decision-Making (MCDM) which seeks to ascertain the 'best alternative', (or option) given multiple sets of decision criteria; the desired alternative itself, being derived from a range of multiple or possible alternatives. This is supported by Ekel et al (1999) who recognised that MCDM techniques in application, are associated with the requirement to solve a given problem in which the solution (and solution consequences) cannot be measured against a single criterion.

Notwithstanding the clear definitions regarding the act of decision making in terms of 'process' and in terms of 'motivation', there seems little doubt from reviewing the literature, that the process cannot be fully 'automated' to essentially run itself, but a degree of subjectivity is unavoidable to address the specialist subject area in question. Kishk (2001) confirms this point in his assertion that the 'classical' MCDM techniques are founded on the respective determination of criteria weighting and alternative rating, both of which are led by the subjective and targeted input of the decision makers' judgements and/or preferences.

Again; this reiterates the earlier distinction between the decision-making activity in terms of 'process' and in terms of 'motivation'. The motivational aspect of the decision making requirement can only be addressed through the identification of well defined criteria, as stated by Braunshweig et al (2001) that decision makers…

"…have to know the critical issues involved and these are usually veiled at first"

The immediate observation when discussing a subjective component of an (ostensibly) numerical or algorithmic process, is the challenge in measuring an intangible factor (e.g. aesthetic performance, effect on well-being etc.)

This is the point where the 'motivational' or subjective aspect of the decision-making activity, is transposed into the 'process' aspect that will allow the required computational ability for the model or algorithm to progress. This is framed well in general terms, by Triantaphllous (2000 pp. 5-6) three suggested steps for any decision-making method which would involve the numerical analysis of alternatives, as discussed above.

1. *Determine the relevant criteria and alternatives.*
2. *Attach numerical measures to the relative importance of the criteria and to the impacts of the alternatives on these criteria.*
3. *Process the numerical values to determine a ranking of each alternative.*

This though, is also a fairly simplistic approach, which seems to 'outline' the issue of decision making without capturing the process 'holistically'. This can be seen when compared against Kolokosta et als (2009 pp.124) later suggested approach in which the process is expanded to include seven distinct steps.

1. *Identification of the overall goal in making a decision, subsidiary objectives and the various indices or criteria against which option performance may be measured (objective function)*
2. *Identification of the alternative options and strategies.*
3. *Assessment of each option and/or strategy performance against the defined criteria.*
4. *Weighing of objectives or criteria.*
5. *Evaluation of the overall performance.*
6. *Evaluation and ranking of options.*
7. *Sensitivity analysis.*

A key connection between the two examples of process shown above, is that the decision maker is required to identify criteria, identify alternatives, and to utilise *some form* of methodology that will allow for these to be compared, ranked, and assessed.

2.8.2 Generic Model Forensics

It seems evident then, that decision-making as an activity, is not merely an arbitrary process on the part of the decision maker but, in managerial and scientific terms at least; it is a process constructed within a fairly well defined set of steps. However, despite the guiding parameters offered by the use of a system or process, the 'art' of decision-making (especially in the context of multiple criterion and alternatives) presents challenges from the outset.

Trianttaphllou (2000 pp. 5) identified what he termed "the decision making paradox", with the logical observation that, given the range of models in use, weighed against the generally unique set of alternatives (especially in regard to the subjectivity of criteria selection), a decision making method seems the only true way of establishing what the correct decision making method should be. This is a fascinating point and illustrates the complexity and arguable validity of the decision making process and model selection. Again, this takes the issue back to the input requirement of subjective parameters, as ultimately a decision (or range of decisions) must be taken on how and what the model will actually decide. Further to his observations on the paradoxical nature of the activity, Trianttaphllou (2000 pp. xxvi) prefaced his book with the caveat that this is the core reason for the necessity of a comparative approach when reviewing or considering MCDM models. This reasoning is sound in the sense that there must be a limit to any models scope to target the problem areas considered. Kolokotsa et al (2009) provide a good example of this approach in the context of energy efficiency in building design in stating that…

"…the objective is to achieve the best equilibrium between the essential design parameters versus a set of criteria that are subject to specific constraints."

Kolokotsa et als observation seems to be essentially, an instruction that to achieve an *optimal* solution, a process of 'trade offs' must be considered. How these trade offs are decided is perhaps the foundation stone for any MCDM approach, or as presented by Trianttaphllou (2000 pp. 23), the first step "in any MCDM problem", is the definition of alternatives and corresponding criterion by which the alternatives will be evaluated. It is critical however, that sight is not lost on the issue of the requirement for trade offs, as these are the subjective heart of any model. This is reinforced by a further example given by Allane et al (2007) who identified (in their respective model) the necessity to employ and determine a system of trade offs between the environmental performance of a residential energy system, and the cost. This use of 'cost' as a trade off factor is significant, as regardless of any other criterion, it is probable that this will be a constant to be factored into any decision making process. This is supported by Burer et al (2003) who identify cost within the MCDM process, as a trade off factor in regard to heating, cooling, and power generation systems. What is of added interest in Burer et als observations, is that cost is matched as a co-trade off factor alongside CO2 emissions. This concurs with earlier comments within the literature review which aim to demonstrate the simplistic connection between the process of CO2 emission (and associated atmospheric release), with the 'real cost' of energy units consumed. This highlights the integrated nature of the sustainability model and it's direct application to the process of MCDM. Allane et al (2007) frame this issue succinctly in observing that should a decision be based upon cost minimisation, then the decision process is a simple one i.e. the cheapest option. However (and especially significant in relation to environmental practices or sustainable technologies), the counterweighted "burdens" are often higher cost for higher efficiency, so yet again, the trade off necessity becomes apparent.

2.8.3 The Need for the Comparative Approach

The earlier highlighted observations by Trianttaphllou (2000 pp. xxvi) regarding the importance of a comparative approach to identifying a suitable model for a given situation are, by the subjective positioning of the decision maker, inextricably linked to the fellow subjective issue of trade offs. This connection and directed methodology, although logical, is nevertheless still presented as a philosophical, even abstract, observation of model selection and usage. This is insufficient for an overarching review or appraisal of the myriad models in use. To review and demonstrate the attributes (in the sense of both perceived strengths *and* weaknesses) and the actual *mechanics* of the model types, a selection of the main, or most commonly recognised model types must be reviewed.

The review must restrict itself to a selection of models to allow practical manageability. This parameter is supported across the literature, from Lokens (2005) observation that there are "literally hundreds" of models which have been proposed, to Trianttaphllous (2000) underlined point that there are a "plethora' of alternative methods which have been developed over the years.

2.8.4 Model Types and Methodologies

This section of the review is titled with the double intention of examining model *typology* and model *methodology*. The distinction may be perceived as a subtle one, yet as the literature demonstrates, the differentiation is significant. Trianttaphllou (2000 pp.1) points out very early in his work the 'humungous' and 'continuously increasing' number of models constantly being developed. This impracticality in reviewing all models in use, nevertheless directs the review to consider the methodologies from the higher level. Zimmerman (1996) offered the separation that on the one hand there exists multi-objective decision making (MODM) used in problems of a 'continuous', or mathematically oriented problem, whereas multi-attribute decision making (MADM) focuses on the 'discrete' problem areas. Discrete in this context describing a predetermined set of decision alternatives (Trianttaphllou. 2000). Together, both MODM and MADM are sister methodologies of the over-arching MCDM process. Table 2.8.4 presents a visual summary of the main differences between MODM and MADM, as it is considered significant that the strengths (and therefore potential weaknesses) of each approach are understood.

Comparison Criteria	Approach Name	Approach Characteristic	Approach Name	Approach Characteristic
Criteria defined by	MODM	Objectives	MADM	Attributes
Objectives defined	MODM	Explicitly	MADM	Implicitly
Attributes defined	MODM	Implicitly	MADM	Explicitly
Constraints defined	MODM	Explicitly	MADM	Implicitly
Alternatives defined	MODM	Implicitly	MADM	Explicitly
Number of alternatives	MODM	Infinite (Large)	MADM	Finite (Small)
Decision makers control	MODM	Significant	MADM	Limited
Decision modelling paradigm	MODM	Process-Oriented	MADM	Outcome-Oriented
Relevant to	MODM	Design/Search	MADM	Evaluation/Choice

Table 2.8.4: Demonstrating the fundamental differences between the adoption of the MODM approach (continuous) and the MADM approach (discrete) Adapted from Mendoza and Martins (2006 pp.2)

Loken (2005) presents MCDM as alternately being called, multi-criteria decision analysis (MCDA). His reasoning for doing so is to separate the arguably subtle issue of MCDA to act as a *decision making aid* as opposed to a *decision making method*. This is a valid point in highlighting that a methodology in itself, does not have the capacity to actually make a decision per se, and this 'aid' is required by the decision makers in achieving a satisfactory and workable end result. So, given that the MCDA is a pre-cursor to the application of the actual MCDM, it is instructive to categorise the MCDA 'schools of thought'. In their 2002 work *Multiple Criteria Decision Analysis: An Integrated Approach*, Belton and Stewart (2002 Kluwer Academic publications) identified three distinct MCDA model types, as being:

- Value measurement models
- Goal, aspiration and reference level models
- Outranking models

Generally, most of the multi-criteria decision making models themselves, can be assigned to one of the above-mentioned categories. This is an important point in understanding and appreciating methodology (and therefore relevance and suitability) of a given model when assessed against a specific problem area. Each is considered upon its own functions and merits below.

2.8.4.1 Value Measurement

Loken (2007) describes the value measurement model as the assignation of a numerical score (or value) to each alternative considered. This is reinforced with Belton and Stewarts (2002) description that the construction of the numerical scores is to represent the 'degree of preference' of one decision *option* over that of another. It is critical to clarify at this point that although Lokens description concentrates on the value of the 'alternative', the initial activity is to assign a *weighting* to each of the criterion, which are to be considered. Loken does clarify however, that the subjective importance assigned to each criterion by the decision maker is a key indicator of the willingness to consider and accept 'trade offs' between criteria. Mendoza and Martins (2006) identify a more flexible framework which allows value measurement the capacity to impose a sense of order and discipline within the process, assist the decision maker in understanding and justifying their own values, and crucially, to "encourage explicit statements of acceptable trade offs between criteria"

2.8.4.2 Goal, Aspiration or Reference Level

This method, which Loken (2007) refers to as *goal programming* (GP) takes what may be termed a 'deconstructive' approach, in the sense that the ideal, or as Belton and Stewart (2002) term it "…the most desirable or satisfactory levels of achievement…" option is presented as a starting point. There seems little doubt that this approach has merit in allowing the DM(s) to begin with a clear focus on the most suitable objective. The caveat it would be assumed, that the decision maker actually *has* a clear idea on what the most desirable outcome or objective may be. As a process however, the mechanics are sound with the systematic elimination of non-suitable alternatives until a level of performance, or outcome, satisfactory to the decision maker has been reached. Mendoza and Martins (2006) add the valid point that the GP method has great strengths in a scenario whereby difficulty is faced in expressing either the importance of weights or trade-offs between criteria. They continue to highlight the dynamic aspect of the process, which allows the decision maker to approach the process iteratively by backtracking through the elimination process itself, and recycling as required. This actually has similarities with the Deming Cycle type approach discussed earlier in the context of the EMS, but perhaps more generally, may also be compared in the context of the iterative nature of the design and specification process itself.

2.8.4.3 Outranking

As implied by the name itself, the outranking models are based on a process of comparison and selection resulting from the most favourable comparison made. Belton and Stewart (2002) state that the process is initially carried out in terms of each criterion by means of the *Pairwise comparison* technique. Loken (2007) is more direct in the context of the process name in identifying that once all of the criteria have been compared and aggregated (as per Belton and Stewarts approach given above) the models function is to then determine which of the alternatives outranks another. Described this way in non-mathematical terms, the process seems fairly straightforward. Mendoza and Martins (2006) succinctly present added strengths to the outranking method in noting that in addition to the Pairwise evaluation process, the ability to identify *incompatibilities* is possible. This is in addition to the capacity to assess both preferences and indifferences. Given the direct ranking and comparative nature of this model as described above, the outranking method is proposed by Greening and Bernow (2004) as being ideally suited to an initial screening process of categorising alternatives into those that are deemed acceptable or unacceptable, as opposed to use in actual alternative selection. This seems a valid proposition and raises the issue of mixed methods application, whether as a potential 'hybrid' model, or as indicated by Greening and Bernows suggestion, a separate step or phase within a multi-model application.

2.8.5 The Decision-Making Process in the Context of Scale

The process, or activity, of decision making, is all around us. In reference to the earlier discussion identifying the importance of 'scale' in regards to climate change and adaptation, this is no different for the decision maker when faced with the requirement to find a 'best fit' solution. Bouyssou et als earlier presented definition of the decision and evaluation models (within the context of formal techniques) focusing on the 'explicit and well-defined rules' still holds strong, and yet the scope and affecting factors of a developing decision-making model must be understood in the context of both scale and necessity.

Lokens point is also reiterated, in that, decision maker (at the most fundamental level) is concerned with attaining what he terms the "optimal solution". This is highly significant. Up scaling the importance definition and relationship to scale, De Boer et al (2010) present this in the context of the climate change 'mitigation' versus 'adaptation' argument. Mitigation in this sense, being the endeavor of reducing the source reasons for proposed climate change, and adaptation accepting that climate change events are occurring and taking physical actions as necessary. Historically viewed as two completely separate issues, the growing frequency of extreme weather or climate related events seems to have forced these two issues together. Skirting the climate change argument, the undeniable fact is that these extreme weather events 'are' happening and as such, decisions in regard to adaptation strategies are becoming far more mainstream.

In application to the adaptation of the healthcare infrastructure, the decision maker is immediately confronted with the need to consider the issue in the context of scale. Governmental and institutional policy and guidance are becoming increasingly familiar to the Facilities Managers, Estates Managers, Healthcare Practitioners, and Design Teams associated with the physical interventions to the built asset. However, in practice, these may be viewed as merely identifying the high level issues associated with climate change and adaptation, without any 'facility specific' direction on 'how' to best proceed. Morrisey et al (2011) agree with this perspective, suggesting that there is a noticeable weakness in the integrated decision making process for infrastructure projects, specifically at the 'micro' level. In terms of the actual realization of adaptive benefits to the facility, the decision making process itself is only part of the process. The NHS, as a publicly funded body, is subject to strict controls and requirements as evidenced (for examples sake) by the *Scottish Capital Investment Manual* (2010), which clearly states the 'duty' of the decision makers to demonstrate that 'Value for Money' has been achieved. This is arguably, an extremely challenging task in terms of provenance, unless the decision making process can be measured and quantified. How could the observer know, that the decisions undertaken within the early design and specification stages address both the adaptive requirements of the facility in terms of extreme weather resilience, whilst also demonstrating that this has met the mandatory 'duty' to demonstrate that Value for Money has been achieved?

There is no simple solution, nor (and mirroring the general ethos of all multi-criteria decision making techniques) is there necessarily an absolutely right solution. In this context, the decision maker is presented with the challenge of finding a 'best fit' solution, which is subject to compromise and trade off, dependent upon the unique specifics of the facility and business case in question. Zarghami & Szidaroszky (2011) capture the main dimensions of the decision making process in suggesting five step process (Table 2.8.5)

Step	Activity
1	Identify Goal (and Objectives)
2	Identify Criteria
3	Identify Alternatives
4	Alternatives/Criteria Evaluation
5	Make Decision

Figure 2.8.5. Five Step decision making process (adapted from Zarghami & Szidarovszky 2011)

The decision making process is fundamentally a human endeavor, and as such it is argued that the process can only be automated to a degree. This is more prevalent the more detailed the issue becomes in regards to scale. Morrissey et als (2011) identification of the weakness in this 'micro' scale is reiterated. Regardless of the high level commitments and political rhetoric in regards to the dangers, wants, and needs of issues relating to climate change and adaptation; it is at the point of Client/Design-Team/Stakeholder interface, where the 'real' physical interventions are made; these being in turn, as the result of 'some form' of decision making process.

CHAPTER THREE CONTEXTUAL BACKGROUND

3.0 Introduction

The literature review chapter has undertaken an extensive investigation and, to an extent, analysis, of the core subject areas critical to the development of the aims and objectives of the research. It can be seen that throughout the chapter, the research questions have begun to evolve in the context of the identified subject areas, and more importantly, their integrative connections. However, despite the thoroughness of the review (and in fact, as a direct result of it), two key areas have been identified which are critical components for understanding the proposed models development, and shaping the conceptual and physical, design and construction, respectively. These areas (in relation to the NHS and it's built assets) are:

1. The capital investment process
2. The estates/asset management process

Both of these processes are requisite aspects, which must be understood to provide context and parameters to *all* facets of the models development. The nature of both of these processes however, is that of a mandatory management system, or approach, and as such lends itself better to a stand alone discussion of both from a *contextual* basis, as opposed to a review of the literature.

3.1 Main Capital Investment Guidance

In the United Kingdom, the National Health Service (NHS) and its built assets are predominantly funded by the public purse. Notwithstanding the fact that many of the GP surgeries and other primary and community care functions are carried out in leased premises, the vast majority of the secondary care and acute facilities are paid for by the taxpayer. The use of taxpayers money to fund the construction or refurbishment to a hospital facility demands that the process is transparent and accountable, and the prime mover in investment terms is not necessarily to return a profit per se; clarifying the point further, the key aspect of public finance investment is to ensure that the tax funds invested into the project are used in the best way possible to contribute to and improve the public (or societal) good.

It is suggested that it is illogical, that projects which have been financed by public investment, are only measured in terms of success, once the project is complete. This approach focuses on a retrospective evaluation of the decision-making process, as opposed to a pro-active, and measured activity. This does not contradict the fact that a 'lessons learned' or 'post occupancy evaluation' is excellent practice on every project. It is perfectly reasonable that bad or incorrect choices made in the past, will still provide benefit by informing the future. The key aspect of the various Capital Investment Guidance documents is that a process of 'appraisal' is undertaken prior to works commencing. The UK governments (HM Treasury. 2003) definition of appraisal states that it is…

"The process of defining objectives, examining options, and weighing up the costs and benefits, risks and uncertainties of those options before a decision is made"

This definition is concise yet descriptive. A clear need for a system or framework with which to consider the project against, is described by the need to define objectives. The end product or output specification *must* be visualized and agreed to allow the appraisal process to even begin. The remainder of the definition is primarily focused on the decision-making processes. This is an extremely significant point, as the reference to options, weighing (weighting), and the decision making itself are all comparable to the widely recognised decision making process proposed by Zarghami & Szidarovszky (2011) shown previously in Table 2.8.5.

The aim of the Capital Investment Guidance documents and processes they describe can therefore be viewed from two interlocking perspectives. The most obvious of these is for the decision makers involved in the appraisal process to select the most economic option. Andrew and Pitt (2004) summarise the second factor as allowing the decision makers' awareness and understanding of the 'real economic cost' of selecting an alternative, which may be required on grounds of policy. Given the nature of the hospital and the service requirements themselves this understanding is essential to allow for any process of comparison or 'trade off' to be established. It is surprising therefore that within the main Capital Investment guidance, there is very little reference to the use or requirement for the use of Multi Criteria Decision Assessment (MCDA) techniques. The area of 'Risk Management' presents the most comprehensive use of the methodology, but this is restricted to the parameters of its own discipline. High-level weighting and scoring exercises do appear in very basic forms (as in the Scottish Capital Investment Process) and are discussed in greater detail, throughout the chapter, but overall, there is no formalised framework or model, which follows the measured process of Zarghami & Szidarovszky (ibid) described in Table 2.8.5.

Although similar in intent, there are various Capital Investment Guidance documents in use throughout the UK and its devolved regions. In regards specifically to the appraisal and procurement of healthcare facilities within the NHS, and within the limitations of the research scope, two main reference documents and processes have been identified and described in greater detail. These are:

1. The Green Book
2. The (Scottish) Capital Investment Manual

The Capital Investment Manual shown in item 2 (above) has 'Scottish' in parenthesis. This denotes the fact that there are both English and Scottish revisions of the same document. Although the Welsh and Northern Irish administrations also have their own versions; these have not been included within the research.

3.1.1 The Green Book

The HM Treasury Green Book: Appraisal and Evaluation Central Government is the main UK reference document from which all of the devolved or regional Capital Investment procedures are guided. The 2011 revision provides the definition that:

"The Green Book describes how the economic, financial, social and environmental assessments of a policy, programme or project should be combined" (HM Treasury. 2011)

This definition should be expanded upon to identify the wider reference to the consideration of 'policy'. This demonstrates that the Green Book is not restricted to the appraisal of projects concerning the built environment or assets, but has more embracing mandate which considers the extent and application of regulation and other appraisal or audit requirements. The main driver for the Green Book is however economic, and the appraisal processes are very much geared towards this. As shown in Figure 3.1.1, the possible outputs of the economic appraisal or evaluation has inroads to many differing areas which do address the 'non-financial' aspects of the complete appraisal process. The guidance offered within the Green Book on the 'non-financial' aspects of environmental impact are brief, and signpost further information available from the Department for Environment, Food and Rural Affairs (Defra), and the Department for Transport (DfT).

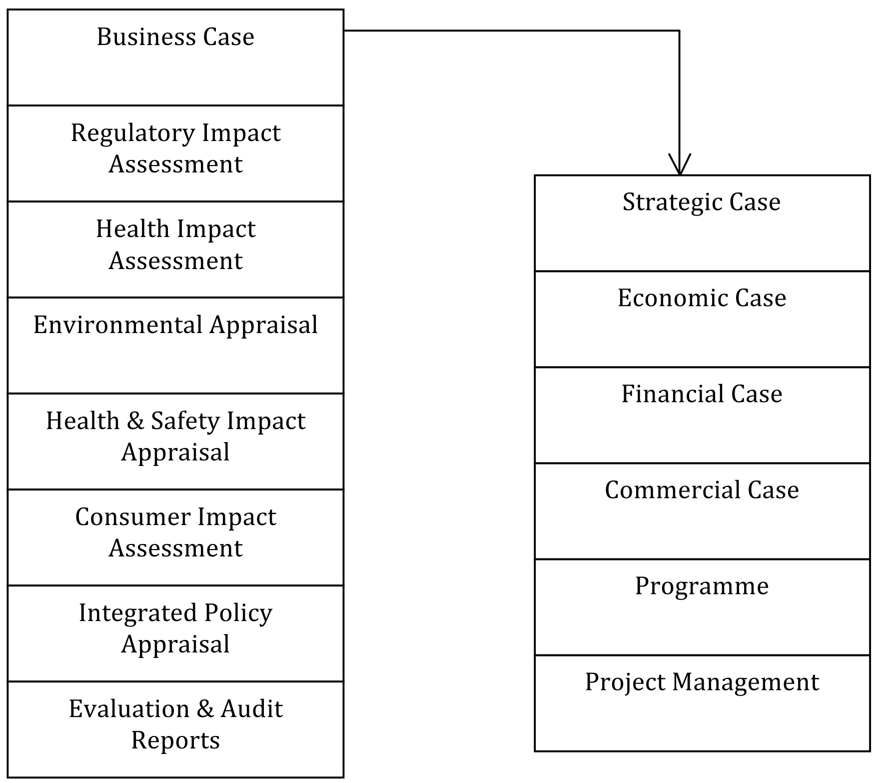


Figure 3.1.1. Possible appraisal or evaluation outputs showing the main case requirements for the Business case. (Adapted from HM Treasury Green Book. 2011. pp.6)

Although the guidance is signposted, as described above, the approach within the Green Book is predominantly high level, and is concerned primarily with policy aspects. The most detailed descriptions in relation to environmental criteria are given as:

- Policy impacts on greenhouse gas emissions.
- Vulnerability assessment on climate change impact
- Air quality
- Landscape
- Water
- Biodiversity
- Noise

All of these however, are presented in the context of assigning or assessing a monetary value to satisfy the core aims and objectives of the Green Books purpose. This is perfectly reasonable given the self-stated purpose of the document, although the almost complete lack of reference to the term 'sustainability' throughout the guidance is noticeable by its very absence.

Despite the references to environmental aspects and appraisal as discussed; the detailed evaluation of the environmental and sustainability aspects is devolved to the user/stakeholder by means of the detail contained within the Business Case and it's 'sub-case' stages shown in Figure 3.1.1.

3.1.2 The Capital Investment Manuals

The respective English and Scottish Capital Investment manuals are focused very much towards the economic considerations and impacts of planning and delivery of publicly financed infra-structure projects and built assets. Unlike the Green Book, the onus is lighter on the high-level policy and regulatory aspects. Both versions of the manual consider the policy implications of the project at an early stage of the Business Case process as part of *establishment* (English. NHS Executive 1995), or *agreement* (Scottish. The Scottish Government 2010) of the strategic context.

Although the wording between these two documents may be slightly different throughout, the general rules and guidance (based upon the platform of the Green Book) are generally the same. Despite the overall similarities however, the versions of the manual are separated by a significant time frame. The English Capital Investment Manual still operates on the 1994 publication, whereas the Scottish version (SCIM) was last revised in 2010. The three core stages remain the same between the manuals, and address (in order of completion):

1. The Strategic Context
2. The Outline Business Case (OBC)
3. The Full Business Case (FBC)

The dates of publication of each version present the greatest disparity between the guidance. The key area of differentiation is in the manuals recognition and integration with the procurement vehicles considered under the umbrella of *Public Private Partnerships* (PPP). The 1994 publication date of the English CIM version pre-dates the developed PPP procurement vehicles, aside from the PFI. The PFI was rolled out in the UK in 1992, so although the CIM does make reference to this process, it must be borne in mind that PFI was still a relatively new process upon the 1994 CIM publication. The CIM does identify a section that encourages that solutions be found using private sector capital, and makes reference specifically to the *Private Finance Guide* (NHS Executive. 1994) identifying as the key points:

- Joint ventures
- Provision of capital-intensive services under contract
- Leasing
- Forward sale of land

The Local Improvement Finance Trust (LIFT) programmes, and the Procure 21 procurement vehicle, were both rolled out on projects in England in 2001 and 2003 respectively. In terms related to the construction industry, and the rapid and significant changes which occurred between the mid 1990s and the first decade of the new millennium, the somewhat specific and dated aims set out in the CIM regarding PPP were simply not written to address these new procurement paths. Granted; supplementary information regarding the evolution of the procurement vehicles has been provided, but the fact that the last CIM revision was in 1994 naturally means that the guidance is a 'bolt on' and retrospective addition to the CIM. The Scottish Capital Investment Manual (SCIM) however, has a different context on the inbuilt integration of PPP schemes within its text. Although the process is (as described above) largely the same in principle, connectivity with 10 step business case process is far more aligned, especially in the Initial Agreement (IA) and Outline Business Case (OBC) phases. This 10-step process is considered within the overarching appraisal and procurement process that the NHS boards consider, beginning with the assessment of the capital project within the identified 'designated limits'. The designated limits are project values with are the threshold markers for the type of business case and sign offs that are required. It follows that the higher the project value, the less autonomy the NHS board will have in the ultimate approvals process for releasing finance. The Scottish Government (Online) provide figures for potential capital levels (and business case requirements) as being:

- Less than £1.5 m value: Standard Business Case
- £1.5m - £5m: Initial Agreement and Standard Business Case
- £5m+: Initial Agreement, Outline Business Case, Full Business Case.

All PPP schemes however, are required to seek higher approval than the NHS board itself, and so there is no delegated limit aspect to be considered in this case. The PPP Guide which forms part of the SCIM suite (The Scottish Government. 2009) makes the point that 'all procurements' which will require capital expenditure must (normally) be considered against the use of PPP models of procurement. It goes on to give guide figures for PPP consideration, to be in excess of £20m, although value for money has been achieved in the £5m to £20m project value bracket also. Attention is drawn to the activity of 'bundling' projects at this stage. The LIFT scheme and Procure 21 suite have the capacity to incorporate multiple schemes rather than a single capital project, which allows the use (and validity) of the PPP process to be applied to a succession of smaller scale schemes which are, for all intents and purposes, regarded as a single value capital project. This is the same philosophy that drives the Scottish *Hubco* initiative in allowing the freedom to 'bundle' smaller value projects into a more financially attractive 'single' scheme.

This 'bundling' approach seems to have especial merit when considered against the need to refurbish, as opposed to starting the capital project from scratch. The question arises from this, of 'what is refurbishment?', and at which point does the issue of maintenance become a refurbishment project? Regardless of definition or semantics, it is reasonable to suggest that in many cases, the scale of refurbishment in terms of cost would not justify a PPP approach, and this echoes the guidance on the NHS Boards autonomy in regards to delegated limits. The non-PPP route is recognised within the SCIM PPP guidance (ibid pp.4) although the requirement for the business case process to be followed (albeit with differing sign offs and business case stage requirements) is still in place. Appendix 2a (ibid) of the SCIM PPP guidance makes clear reference to the challenges faced with refurbishment works when considered against new-build. Not only are refurbishment projects more likely to present less scope for efficiencies (design, FM delivery etc.) which has the corresponding negative effect on potential profit or value for money; the nature of refurbishment works themselves are widely regarded as being unattractive in respect of uncertainty and risk. (Egbu & Lee., 2006) (Azlan-Shah., 2010) (Quah., 1988) (Aho et al., 1998)

It has already been stated that all capital investment projects *must* provide a business case, regardless of value. Although differences are found throughout the process in regards to the FBC stage and approvals procedure, the common denominator remains unchanged in that the early stages i.e. Strategic Assessment, and development of the Outline Business Case are still required. It is from these common early stage activities where the best 'value for money' opportunities are to be found on practically all projects, regardless of refurbishment or new-build. This appreciation focuses the most optimum area of intervention of the decision making process, including the utilisation of an integrated decision-support model, to be considered within these common and mandatory time frames.

3.2 Integrating Sustainability within the Capital Investment Process

All three main guidance documents that are considered (Green Book, Capital Investment Manual, Scottish Capital Investment Manual) are naturally integrated by the nature of the hierarchy. The Green Book is the over-arching guidance document, and the CIM and SCIM are essentially the same document, but separated by publication date. The SCIM is a far more integrated document, although the CIM has been appended with a raft of supplementary appendages to address the evolution of various PPP Procurement vehicles, which have developed since its publication in 1994.

It is critical to understand the main drivers and motivations from all of the capital investment appraisal documents. What is evident in the *Green Book* definition is that all three dimensions of the *Sustainability Model* (Economic, Social, and Environmental) are presented. This in itself is an excellent indicator of the differentiation between 'sustainability' and 'environmentalism', which are viewed as the same issue in many quarters. However, the definition recognises a fourth dimension by identifying the 'financial' aspect. On the face of it, the question may be asked:

What is the difference between the economic dimension and the financial?

This is an important distinction, and it is recognised within the most recent appraisal guidance (being the SCIM), that the financial appraisals and the economic appraisals are very often confused (SCIM. pp 119). It should be understood that the financial case is dependent upon the construction of the economic case. Essentially the financial case is a *micro* oriented approach, which seeks to ascertain the affordability of the options that have been considered on the *macro* (economic) level. This is especially geared towards a financial appraisal of the preferred option. The 'preferred option' is itself open to misinterpretation and confusion, as this may be confused with the 'preferred way forward', which is actually a more strategic appraisal of the potential options, also referred to as the 'long list'. The preferred way forward is the final action undertaken in the strategic phase, also referred to as the

Initial Agreement (IA). This is also the final part of the first draft of the economic case before moving into the Outline Business Case (OBC) phase.

This brings the discussion back to the differentiation between the economic and the financial dimensions, as the financial case will be made later in the OBC phase, based upon the economic case made at the outset. This is of critical relevance to the placement of the decision making process, as linking the first step within the OBC phase, is not only identified as the continuing economic case, but also described overall as "Determining Value for Money" (SCIM pp. 57).

It is 'Value for Money' (VFM) which is the common thread that ties all of the documentation and appraisals guidance together. Irrespective of procurement path selected, the assignation of public funds on 'any' capital investment project *must* demonstrate that the best VFM has been achieved. Understanding this over-riding concept is absolutely key to assessing the optimal placement of a structured decision making process. The SCIM actually states that one of the key aims of the OBC overall, is to…

"Identify the option which optimises value for money (VFM) and overall sustainability" (SCIM pp. 57)

It may be argued that the identification of VFM in this context is in fact a superfluous statement, as the economic aspect of the sustainability model referred to, incorporates this as a matter of course. Granted, the financial case (Step 6 in the SCIM) of the OBC has already been identified as sitting out-with the sustainability model dimensions. The argument however, swings back yet again to propose that it is the macro (economic) decision making opportunities early in the business case process, which present the best VFM opportunities to the project overall, as the micro (financial) case, is in many ways a reactive activity working within the pre-determined parameters of the 'preferred option' which is the intended output of Step 4 (Determining VFM). Although there is always scope for pursuing VFM, Step 6 within the OBC (Ascertaining Affordability and Funding Requirement) presents far less scope for doing so, as the focus is to address *cash flow*, as opposed to VFM based on Whole Life Costing (WLC) principles.

It is commonly understood that the earlier that decisions are made in the project life-cycle process, the better VFM will be achieved. This is for a number of reasons, one of the most prominent in this context being the minimization of variations or changes to the design or specification as the work progress. In the context of refurbishment, and especially when considering the complexities and adjacencies of a hospital, the requirement for a rigorous, structured, and timely decision support model becomes increasingly essential. The lack of appreciation of a decision making process within the refurbishment process can be appreciated from the main guidance document (The Green Book) itself which states that…

"With newly built assets, consideration has to be given to design, whole life costs, fitness for purpose, operational efficiency, and end of life costs as well as the initial impact of capital payment" (Green Book pp. 69)

There can be little argument to the clarity of direction given within this statement, although the focus on 'newly built' and complete omission of refurbishment is surprising. No more so is this omission felt than in the field of *hospital* refurbishment. It can be argued that the documentation (in its entirety) is only 'guidance', and that a reasonable perception will understand that this approach should be applied to the 'project' regardless of whether it is new build or refurbishment. It may also be argued however, that without specific guidance which identifies what is largely considered to be a more risk probable area, then structure is lost, and with it potential 'opportunity'.

3.3 Placing the Decision-Support Requirement

In considering the requirement for a decision support model, it must be accepted that the entire appraisal process, and the business case process (complete) is a series of steps, actions, and events, which are connected by a continual and multi-variate set of decision making processes. The thesis discusses and evaluates the decision making process and the tools available for its undertaking in detail elsewhere, yet it is imperative to understand what the current 'formalised' decision making processes as recognised by the guidance and the business case process, consists of. The integrated sustainability model designed within the research needs to be placed within the optimum intervention points throughout the process, and must include the correct actors and stakeholders who are firstly; essential to the process, and secondly; desirable in pursuing the best possible outcome, *relevant to the specific project,* and this will be a key observation throughout Chapter 6.

The first step towards understanding 'where' the decision making process will be placed, is to review and understand the current practice. The caveat must be raised at this point, that there is no 'absolute' standard or structure that is replicated on each appraisal or business case process. Although in general, the stages, steps, and actions undertaken do adhere to the same guidance, each project will be unique, and will be undertaken by different stakeholders, all of whom are subject to their own personal perceptions, or indeed the cultural approach of the company or organization whom they represent. It is proposed that this is not necessarily a negative aspect to the decision making process or the progress of the business case and/or project, as decision making in 'design' terms, must logically be fed with a freethinking or creative approach. It is this latitude that allows for subjective input based upon many factors, not least experience or an understanding of a particular projects specifics or unique idiosyncrasies.

3.3.1 Decision Making in the Strategic Context

The decision making process (and therefore opportunities for intervention) are suggested as being most applicable in the later stages of the IA, and early stages of the OBC phases of the business case process. Steps 1 to 3, which output the Initial Agreement, are strategic in nature. As stated previously, the entire process may be viewed as a series of actions connected by decisions, which have been made. This is no different for the strategic context, which are required pre-OBC. The SCIM identifies early, the importance of the strategic context in providing a basis for more informed decision-making (SCIM pp. 27), and although high level in nature, this begins the process of consensus and visualization of a common direction. This is driven in more focused detail as the business case progresses, as evidenced by Action 2.2 which seeks to:

"Determine investment objectives, existing arrangements and business needs" (SCIM pp. 30)

There is some care to be taken at this stage, as the line between decision making and consensus forming seems to be a thin one. The SCIM recognises the investment objective as translating into "what we are seeking to achieve" (SCIM pp. 34) reference is made to the requirement for SMART (specific, measurable, achievable, relevant, and time constrained) targets to be utilized as mandatory, and as a requirement gateway for approval by the Scottish Government Health Department (SGHD). Compilation of the SMART targets (it may be argued), are themselves a decision making process, although there are parameters within these, such as legislative or institutional requirements which *must be met* and are critical in guiding the determination of objectives as quoted above. Examples of these may be the requirements of the *Building Research Environmental Assessment Method* (BREEAM) tool, or indeed design quality objectives. There seems little in the way of detail required at this point, in areas such as reference to the *Health Technical Memorandums* (HTM) or the *Health Building Notes* (HBN) documents (aside from the understanding that many of these are captured within the BREEAM or design quality assessment processes further downstream) It is noted however, that the SCIM does clearly identify the relevance of sustainability implications (SCIM pp. 30) at this stage. There is limited guidance on exactly what is meant by the term sustainability, and focus is centered on the tools and methodologies, however it is suggested that this is a narrow view on the holistic principles of sustainability.

It has been shown that *The Green Book* recognises all three dimensions of the sustainability model, plus specific mention of the financial implication, however, the early stages of the SCIM and the IA/Strategic Context phase channel the user to consider methodological and assessment processes which focus on the *built asset* itself. This is correct, however a lack of structured guidance on *what comprises sustainability*, and *what sustainability actually* *means* has potential to leave the manual user with a limited perspective on the requirements and more importantly, limiting also the opportunities from using embedded sustainability principles from the outset. Having said this, the practicalities of the guidance do not allow for an in-depth description of every facet of the business case, which includes the sustainability model. It is expected that the team preparing the business case make themselves aware of the criteria and objectives set out in other guidance. How well this is carried out on a particular project can be measured with an evaluation of the project retrospectively, and this is a valuable tool in lessons learned. To optimise the decision-making process and value for money for a specific project however, the understanding and subsequent decisions taken needs to happen at the front end, and this is instrumental in positioning the optimal intervention point for the developed prototype. SCIM does recognise specifically the 'Sustainability Objectives' with reference to the requirement for all capital projects to undertake a BREEAM pre-assessment to assess viability (if under £2m project value) or as an indicator of present status in the mandatory requirements for a new build (Excellent) or refurbishment (Very Good). It is important to note though, that the BREEAM assessment is not in itself a decision-making tool or model. It is a description of specifications and performance requirements, which must be achieved in order to attain a specific score or rating. It may even be suggested that the BREEAM assessment (pre-assessment at this stage) is useful as a first step in informing the criteria population of a potential multi criteria decision-making process.

It seems evident then, that aside from the heuristic input from the business case team, or involvement of specialist consultants from the outset, there is no formalised framework to integrate the sustainability agenda and any resultant opportunities within the strategic context. The BREEAM pre-assessment is a useful tool and certainly provides parameters to be considered within the sustainability agenda. Measured against the proposed model however, the results and information collected from the pre-assessment are suggested as most useful for the 'setting of objectives', and the 'criteria identification' phase (Phase 2. Steps 1 and 2 respectively) of the decision making model. The SCIM supports this view when considering ‘constraints’ and improving the ‘value for money’ (SCIM pp. 38). It is made explicit in the guidance that…

“…Late changes or ‘bolt-ons’ do tend to be costly (and generally less effective), so the principle should be to integrate sustainability criteria in from the outset…” (SCIM pp. 38)

In reiteration of what is discussed above, what is lacking is any clear guidance or formalised structure on just *how* this should be undertaken.

3.3.2 Targets and Outcomes

The overarching section framing these requirements is *Step 3 – Exploring the Preferred Way Forward* (SCIM pp. 41) This is validly recognised as a ‘fundamental chapter’ in providing a VFM platform for the continuing business case process. This section has great significance to the models development, as this may be arguably the first main ‘decision making event’. The emphasis is clearly focused on the main choices and/or options, which will be required to deliver the level of service or performance that has been identified on the strategic level. The proposed model follows a differing timeline of the process within the business case, and places this (or certainly many parts of) at the earliest phase of the decision making process. It must be highlighted that this is referring to the activity of ‘refurbishment’. The significance of the connection to refurbishment is that the initial phase of the proposed model is the ‘asset inventory’. The asset inventory is designed to provide a ‘here and now’ status report on what is currently existing, and in what condition. It seems reasonable to suggest that only from a clear understanding of what currently exists, can a comparison be made against what is actually required (whether in legislative or clinical terms). The preparation of the Initial Agreement (Step 2 of the business case process) precedes the exploration of the preferred way forward in the guidance, and there is no argument as to the logic of this. The proposed model however, seeks to measure outcomes, and outputs (and to a limited degree ‘targets’) from the front end. There is a process of decision making required which takes the model through the strategic decisions such as whether to maintain, demolish, refurbish, or indeed, do nothing. The assumption is that the decision to refurbish has been made (itself falling under the umbrella of the Preferred Way Forward), and as such the asset inventory is compartmentalized into the assessment of the existing structure or structures.

Ultimately; the output of the final phase of the strategic context (or Initial Agreement) should be a matrix type shortlist of the main options to be considered (or scope of works) On the basis of the analysis carried out thus far, the end of the IA phase seems to present a natural intervention point for constructing an MCDM model. The high level criteria reviewed and considered to this point, appear to be in terms of 'strategic consensus'. Given the nature of the MCDM process, the level of detail on a measured scale may prove to hinder the process rather than improve or optimise it. The identification and narrowing down to the short listed set of options is therefore considered as a baseline or foundation, containing enough information to allow for more detailed criteria to be considered and added to the decision making framework. This supports the guidance within the SCIM, which begins to open the discussion to the integration of the Business Case process to other PPP type procurement models, in stating…

"In the context of either Frameworks Scotland or the hub initiative, this could avoid a great deal of work done by PSCP (Principal Supply Chain Partner) *or hub partner and their supply chain (at significant cost)"* (SCIM pp. 51)

In other words, the more robust the set of options resultant from the IA, the greater the chance that costly or unnecessarily onerous works may be avoided.

3.3.3 The Existing Decision Making Process and Guidance

It has been discussed previously that the entire business case process may be viewed as a series of actions connected by a continual and evolving form of decision-making. In the strategic context, this is largely by method of consensus. It is therefore surprising that from the three guidance documents under review, both *The Green Book* (HM Treasury 2011) and the *Capital Investment Manual* (NHS Executive 1994) provide no guidance or even clear reference to the activity of decision making as a process. The SCIM (2010) however, does recognise this. Earlier observations in a comparative study of all three main guidance documents, identified the SCIM as being the most updated, and certainly the most integrated document, and this is undoubtedly a reflection of this. This however, is still not strictly provable, as the supplementary guidance available in retrospect to update the CIM (especially), still do not provide direction on decision-making as an activity and a process in its own right. The inference of this situation may be that the art of decision-making has been tacitly devolved to the designers, main contractors, or consortiums, which operate within the 'relatively' new PPP procurement vehicles. Outside of very specific issues dealing with the areas of Risk, and to a certain extent, Whole Life Costing, there is no mandatory requirement, nor even strong guidance, on undertaking a measured and calculated decision-making process. The over-riding VFM approach of the business case itself may bear partial (if not most) responsibility for this. Of the five 'case types' within the business case process, the central three are:

- The economic case
- The commercial case
- The financial case

It speaks for itself that all three are related to money. Again; this supports the over-riding aim of providing VFM for the public purse. Action 4.3 of the SCIM – *Undertake Benefits Appraisal* (SCIM pp.75) that resides within the first section (Step 4) of the OBC (*Determining Value for Money*) This is specifically targeting the non-financial benefits associated with the business case progress thus far. This is the first, and more notably – last, structured decision-making activity undertaken throughout the entire business case (in regard to the guidance documents).

Section 4 of the SCIM (ibid) offers a very basic form of multi-criteria decision-making. It is explicit that this is related to non-financial benefits, and the reasoning behind the model is geared towards the strategic context. It may be argued that by the nature of the connectivity's between issues, there will 'always' be a financial impact, although at face value, the purpose of the model is to step outside of the limitations of economic, financial, or commercial drivers. The SCIM offers example criteria as (SCIM pp.77):

- Quality of Clinical Care
- Patient Accessibility
- Flexibility of Accommodation
- Quality of Hotel Services
- Disruption to Services

These are identified as the 'benefits criteria' or 'attributes' (ibid). Compare this with Zarghami and Szidarovskys (2011) reiterated, five-step process suggested for construction of an MCDM model (Table 3.3.3)

Step	Activity
1	Identify Goal (and Objectives)
2	Identify Criteria
3	Identify Alternatives
4	Alternatives/Criteria Evaluation
5	Make Decision

Figure 3.3.3. Five step MCDM process (adapted from Zarghami & Szidarovszky 2011)

It is clear from Table 3.3.3, that the identification of criteria is an early requirement for the decision making process. The SCIM model takes the Decision Maker in the correct direction, as the weighting and scoring (and subsequent ranking) of criteria must be agreed before considering what the best alternative may be. The question, which must be asked at this point, is:

"Where are the alternatives?"

The SCIM process asks an 'expert and representative' team to agree a set of main criteria, to weight each of these on a suggested scale from 1 to 100, and then to score each option on a scale of 1 to 10, dependent on how well the criteria delivers the perceived benefit. A simple multiplication of these 2 figures then provides a numeric ranking which is referred to as the 'preferred option' within the SCIM (pp 76). Is this *actually* a 'preferred option' or 'best alternative', or may it be argued that this is in fact only a ranking of 'criteria'?

3.3.3.1 The Decision-Makers in the Current Process

Multi criteria decision modeling (in the discrete sense) can be defined as an exercise in transforming the subjective, or the qualitative, into the objective, or quantitative. Triantaphllou; (2000) a seminal researcher in the field of MCDM states from the outset that the MCDM process will always be, and can only ever be, the pursuit of a 'best fit' or 'trade off' solution, given the multi-variate nature of the projects in question and the potentially vast and inter-connected number of criteria potentially applicable. With this in mind, it seems obvious that any decision making process is only as good or effective as the decision makers themselves and the quality of their subjective judgments in regard to weighting, scoring, and ranking.

The question arises at this early stage, of *what, or who, is a suitable decision-maker?*

This question may appear to pre-empt further discussion and research into this area throughout thesis, yet it is considered in the context of developing the contextual background, to be highly significant in understanding the current business case process.

On the face of it, the obvious experience or track record of members of the decision-making team may be without question. Nevertheless, the consensus approach favored by the SCIM presents a hidden decision-making activity in deciding 'who is competent and experienced enough to make the decisions?' The argument begins to be lost in the realms of academic viewpoint at this stage, and Triantaphllou (ibid) accepts this, and makes the point that only by undertaking an MCDM process of all available decision making models, may the most suitable model be selected. This of course places the decision-maker back in the same position, and this paradox has been discussed previously. There may be a similar valid argument in the identification and classification of an 'expert' team. Only an expert could truly assess the competence or suitability of an expert…and so on.

The SCIM states:

"…it is important to recognise that the assigned weights and scores given to options are value judgments. In order to assign weights and scores, negotiation and compromise needs to take place" (SCIM pp. 77)

This is significant and lies at the very heart of the MCDM design. The guidance recognises that the 'benefits team' should include user groups, business users, technical representatives, and more vaguely…stakeholders. How well such a consensus approach would work, will again be dependent upon the knowledge base, the personal or professional bias, and the personalities of the participating members.

3.4 Asset Management in the Context of the Healthcare Estate

Asset Management is too broad a term to assign to the research and understanding of its utilisation in any sector, without providing a clear framework for its use (and therefore its very *meaning*). This is arguably no more prevalent than when considering the scale, diversity, and complexity of the NHS Estate. In the context of the research aims and the proposed models utility, parameters must be given to the definition and scope of the research area itself. John Woodhouse, the Chairman for Developments and Standards within the UK *Institute of Asset Management* (Woodhouse Partnership 2007) identifies the three main dimensions of Asset Management as a discipline. These are:

1. Financial sector use
2. Equipment maintainers and software vendors use
3. Infrastructure or plant owners or operators use

It is not the intention or the purpose in the context of the research, to explore a detailed study of Asset Management per se; and it is recognised that there is necessarily a degree of integration and crossover between the three dimensions given. However, as recognised by the *British Standards PAS 55* specification (ISO 55000. 2012) it is the third aspect concerning the infrastructure which is applicable to the wider NHS portfolio and planning strategy. Mitchell and Amadi-Echendu (2007) provide a relevant and working definition in their consideration that…

"Physical assets utilised as a means of revenue generation and service delivery are expensive, usually represent the major percentage of an organisations capital investment in productive resources and are subject to unprecedented operational demands"

This definition deserves scrutiny in the context of the UKs healthcare estate. The reference to 'revenue generation' may be viewed as non-applicable to a publicly funded institution, and the discussion has the potential to stray on to dangerous political ground. Revenue generation cannot be simply ignored though, as with the current and future Public Private Partnerships and similar procurement vehicles, there is a place for the generation of revenue within the healthcare portfolio. Notwithstanding the potential grey areas when utilizing Public Private Procurement arrangements, the Scottish Government make the clear statement within the *NHS Scotland Local Delivery Plan Guidance document 2012 -2013* (2011 pp.28) that…

"NHS Scotland is a publicly funded and publicly delivered service"

This is a key differentiator between the NHS England approach, which opens up the possibility for a far more profit based approach for the bidding contractor or consortium, and the Scottish approach, which is designed with the intention of public and private arrangements geared towards a more community based non-profit heavy partnership arrangement by such procurement methods as the evolving Hubco.

Another theoretical approach is to interpret the reduction in costs in one or more areas, as a form of revenue generation in as much as the potential exists to divert funding to other priority areas as a result of successful efficiency savings. The view may be held that the discussion is more an issue of semantics rather than a critical point of understanding, however, it is argued that the initial demonstration of the three Asset Management dimensions, and the interpretation of revenue generation as a driver, dictates that a careful approach must be undertaken when applying the discipline, as described by Mitchel and Amadi-Echendu (ibid) to the built assets of the NHS.

There is also early recognition of the evolving key criteria which may need considered in respect of the proposed models development.

Having said this; there is little doubt of the applicability of the 'service delivery' aspect of the definition. The sector under review is the National Health Service. There is absolutely no ambiguity, at this point, that the organisations *raison detre* is the provision of services and operating models of care. The Asset Management argument could rightly be used to consider the services themselves, together with the clinicians and myriad other support staff in terms of being 'assets'. This is a very well understood management principle that recognises people as *the* greatest asset. This is not disputed, and it is clear that service delivery will not occur unless the suitably qualified and motivated personnel are there to deliver it. This raises a significant point on the decision making process itself, as despite the existence of the physical asset, it is human beings whom will make the subjective decisions required for identification and weighting of criteria, which is applicable to the built asset. Woodhouse (2007) asks why operators and technicians are often viewed as skilled sets of hands, with no cultural recognition of the creative potential of their minds and experience. This is of course a general observation, and it should be expanded to include other actors than technicians and operators. It may also be proposed that the general public are as much a part of this as the 'professionals' identified. The general public, from both a patient and community standpoint, do have a place in the appraisal and assessment processes, however, as described in the methodology chapter, the focus here is on the professional participant for reasons of timings and intervention points. The same understanding must be taken when considering the 'unprecedented *operational demands'*. The demands of service provision on a day-to-day basis are borne by the practitioners and staff associated with the service itself. However, the focus is redrawn to the consideration of the infrastructure and the physical assets. The parameters of the research and the research model are focused predominantly on the management context of the built estate portfolio. The *UK Institute of Asset Management* offers the most applicable definition for this approach in describing Asset Management as:

"The set of disciplines, methods, procedures and tools to optimise the Whole Life Business Impact of costs, performance and risk exposures (associated with the availability, efficiency, quality, longevity, and regulatory/safety/environmental compliance) of the companies physical assets"

The reference to a 'company' as opposed to an organisation or institution has no effect on the proposed model. Even within the parameters of infrastructure and its relevance to the NHS, it must be identified that the 'functional specialisms' may naturally self organize in a way that breaks the whole Asset Management picture into workable parts. Woodhouse (2007) suggests these are:

1. Design and Building of the asset (engineering)
2. Exploiting the asset (operations or production)
3. Caring for the asset (maintenance)

The characteristics following the above 'functionalities' in parenthesis are perhaps more interesting in the context of the research than the functionalities themselves. The key activity driving the research project is that of 'refurbishment', and the question must be asked of "where does refurbishment as an activity, interface with each of the characteristics?" The answer must be…'in all of them". This is naturally a key distinction that binds the research together, and this is discussed in detail in the section on defining refurbishment as an activity. It is crucial to highlight that the discussion thus far on the context of Asset Management in the NHS Estate, has not been merely an exercise in word-play and interpretation of definitions, for the sake of merely 'doing it'. Clarity is absolutely essential, not only for the development and operation of the model itself, but in understanding the built estate as an entirety, and subsequently stepping down through asset groupings and to individual facilities. The models function is intended to be adaptable to the strategic, stepping down to selection of alternatives and specification choices. This makes an understanding of the activity, the function, and the objective essential.

3.4.1 The Existing Estate

In order to understand and view more fully the discipline of Asset Management in the context of the NHS Estate, it is informative to take a snapshot of the scale and the make-up of the Scottish portfolio. The Deputy Director of the Scottish Governments *Capital Planning and Asset Management* division held a workshop (Scottish Government. 2011) entitled: "Healthcare Planner Workshop: The Strategic Context" in which he identified the proportion of funding by percentage (Figure 3.4.1a) of Asset Management within the estates annual revenue expenditure.

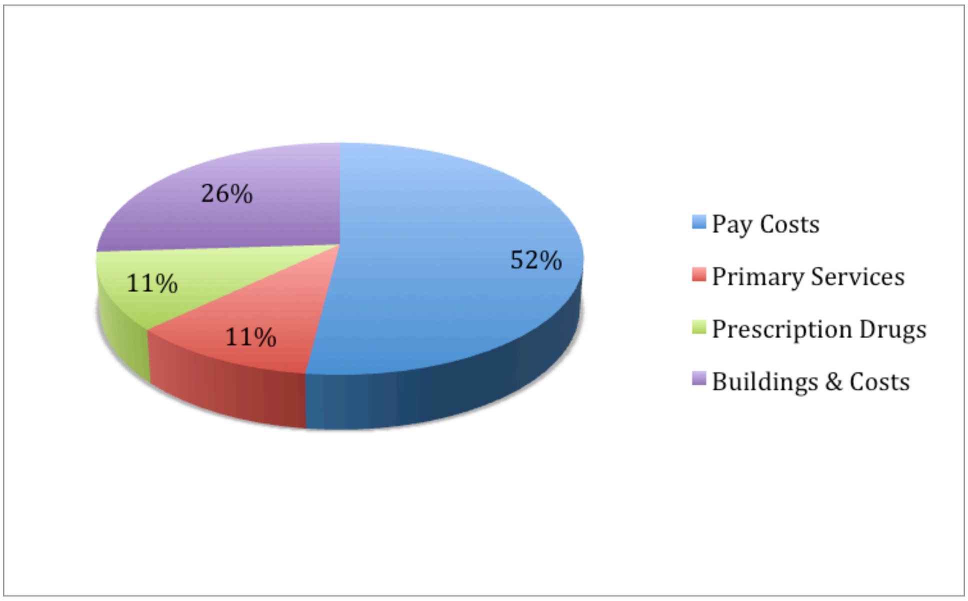


Figure 3.4.1a: Asset Management costs within total NHS Scotland expenditure (adapted from Scottish Government 2011)

Baxter informs us that from an overall expenditure of £10.3 billion, Asset Management (in regards to buildings and associated costs) account for 26% of this figure (Figure 3.4.1a). The worth of the actual assets themselves are valued at £5 billion, so a quick glance calculation demonstrates an annual costs in asset Management terms, that is roughly half the value of the estate itself. It is suggested that an annual expenditure that is circa 50% of the combined assets complete value seems an extraordinary figure to essentially maintain the service in its existing state. This issue has clear connections with the wider economic situation within the UK as a whole, and it is useful to view the built estate through a lens which separates the ongoing maintenance, upkeep and refurbishment aspects of a facility, from the new build investment which has been the result of Public Private Partnership arrangements. Wilson and Kishk (2011) identified that the era of new build, and especially that from the public purse has slowed dramatically and it is from the existing estate (and the maintenance and refurbishment activities required from it) where the efficiency savings and targeted reductions in areas such as sustainability performance, must be met. The *Scottish Governments Health Directorate* (SGHD) released its 2010 publication entitled *A Policy for Property and Asset Management in Scotland* (Scottish Government 2010) to clarify and instruct on the framework requirements for monitoring the performance of NHS Scotland's property assets. It is informative to place the CEL 35 policy within the context of Asset Management as a discipline, and the documents required by the individual Scottish NHS Boards. Figure 3.4.1b shows a hierarchy diagram with Asset Management as a discipline requirement at its peak

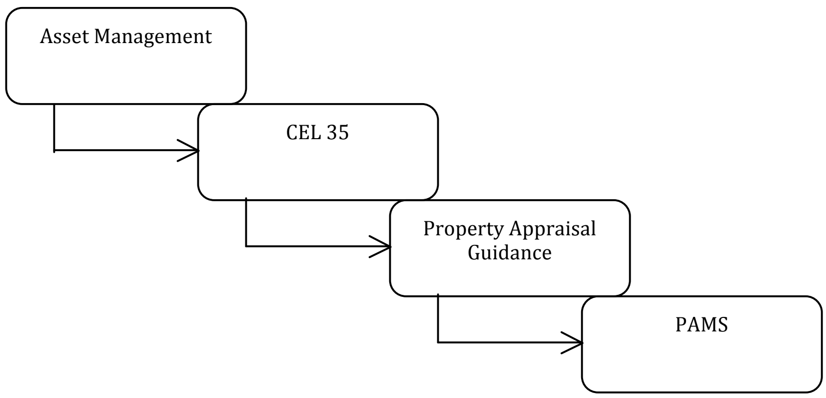


Figure 3.4.1b: Summary overview of the hierarchal relationships of policy and strategy guidance for NHS Scotland Asset Management

It is useful to note, that the documents and systems discussed thus far (Figure 3.4.1b), are by no means stand alone issues within the context of the wider NHS. The point was made earlier regarding the identification of 'the asset' in asset management, and the cascade diagram in Figure 3.4.1b is quite clearly focused primarily on the built assets or physical estate. It would be remiss to ignore the fact that the NHS is by no means just a portfolio of built assets. This point was also discussed in terms of 'what is an asset?' earlier; however, Figure 3.4.1a demonstrates that essentially three quarters of the total expenditure of NHS Scotland is concerned with issues outside of the built estate. A balanced understanding of the asset management and property appraisal process must be framed within the accompanying and integrated documents and guidance produced by The Scottish Government and NHS Scotland, and the often inter-related targets or aspirations within them.

In the context of the research, an example of this integration may be seen from reviewing and comparing the guidance regarding *NHS Scotland's Local Delivery Plans* (LDP) (The Scottish Government 2011). As the name implies, these are delivery plans which must be developed by the individual NHS Boards and actioned within a given timescale, as set out by the Scottish Government. The approach and purpose of the LDPs is focused very much on the clinical and service requirements of the hospital, and this is demonstrated with the clear service focused ambitions which are set out as the key attainment criteria within the 'quality strategy', these being care which is 'person centered, safe, and effective' (ibid pp.4). The measurement targets are separated under four main streams, namely:

1. Health improvement
2. Efficiency
3. Access to services
4. Treatment

These are commonly referred to by the acronym of 'HEAT' targets. The guidance describes the HEAT targets as being areas that have been recognised on a yearly basis for 'specific accelerated improvement' (ibid pp.6). They are framed against the three quality ambitions, which are described above. Suffice to say, that the HEAT targets are geared towards a fairly wide range of clinical and service issues such as waiting times, reducing instances of Health Associated Infection, reducing absentee rates among staff etc. However, there is a clear target and policy aim within the guidance that relates to the requirement of NHS Scotland to…

"…reduce energy based carbon emissions and to continue a reduction in energy consumption to contribute to the greenhouse gas emissions reduction targets set in the Climate Change (Scotland) Act 2009" (ibid pp.11)

When reviewing the full list of HEAT targets, this carbon and energy focused target is actually slightly incongruous with the rest of the policy aims and their clinical aims. This, it is suggested, is an obvious asset management concern, as it has direct connections to property appraisal process (see the 6 facets. Health Facilities Scotland 2010 pp.8), especially the 'statutory compliance' and the 'environmental management' facets. The target descriptor is unambiguous in regards to the statutory compliance facet, as the driver of the *Climate Change (Scotland) Act* is set out within it.

It is stated that one response from the NHS boards in considering their 'complex challenges', is an 'asset based approach' (ibid pp.15) Interestingly, or perhaps frustratingly however, there is no definition or guidance at this stage on exactly what an asset based approach is or looks like. Many of the HEAT targets are not solely driven by financial drivers, and therefore an approach that seeks to concentrate on 'efficiency savings' may not be a natural fit in all instances. Stepping back however, and following the focus of the research project itself, this particular statutory driven HEAT target, the advice on an asset based approach, and the identification of the need for 'efficiency savings', places the discussion back within the discipline of Asset Management as described earlier.

The LDP guidance document states that the Scottish Government has bound itself to supporting modernisation programmes for the service (clinical), and in eliminating waste. Waste is an interesting issue, as this is an extremely wide-ranging area and has potential for great ambiguity. On the face of it, waste may be interpreted as an environmental management issue. This is wholly correct in terms of physical waste management and the economic and environmental implications that go with it. The Environmental Management System of the organisation, the requirements of the Health Technical manual (HTM) and any BREEAM requirements from physical construction or refurbishment works, will all have requirements and guidance in regards to waste management. However, waste can occur in practically every area, and not always necessarily those that are tangible. Water can be wasted through poor supply arrangements or consumption patterns. Money can be wasted on

poor procurement and contractual process, and the more difficult to quantify, 'time' can be wasted on an almost infinite range of issues. As with previous key themes explored, these findings begin to shape the key criteria requirements for the proposed model, and as such, begin to influence the thinking related to the conceptual model design itself.
The Scottish Government categorises efficiency savings in what they term, six key themes. These are:

1. Clinical productivity
2. Workforce
3. Drugs and prescribing
4. Procurement
5. Support services
6. Estates and Facilities

Theme six, Estates and Facilities, provides the final integration link between the wider clinical documentation, as described within the Local Delivery Plan, and the Asset Management and Property Appraisal process illustrated in Figure 4.4.1b.

3.4.1.1 CEL 35: A Policy for Property & Asset Management in NHS Scotland

Asset Management as a discipline has been reviewed. The context of NHS Scotland's built estate has been identified within the physical infrastructure element of the discipline. Figure 4.4.1b shows that the next level down from the discipline itself is the provision of policy (CEL 35). The policy is clear in stating its relationship with the individual bodies requirements to create *Property and Asset Management Strategies* (PAMS) and is not in itself a strategy-monitoring document, but a guidance document informing this. There are comparisons which may be made with the previous discussion regarding the high level discipline of Asset Management itself. A succinct definition is offered to describe Property and Asset Management (ibid pp. 1) process as being to…

"Optimise the utilisation of assets in terms of service benefit and financial return"

This however, is perhaps a poor description in regards to detail, when compared against the definitions from Mitchell and Amadi-Echendu (2007) and the Institute of Asset Management. Between them, these two definitions identify both the 'operational demands' and the importance of the 'risk' profile. SGHD also identify 4 key stages in the process of Asset Management as being:

1. Planning
2. Acquisition
3. Operations and Management
4. Disposal

Compare this with Woodhouses (2007) three functional specialisms (and their characteristics as discussed) of Design and Building, Exploiting the Asset, and Caring for the Asset. The key common denominator across all of the guidance and differing sources of Asset Management definition is the understanding that a prime focus is to attain and deliver 'Value for Money' (VFM). NHS Scotland, (being a public body) has even more stringent requirements placed upon it, in as much as it has a 'duty' to demonstrate 'best' VFM. This point cannot be over-stated, as the validation of the proposed model itself, is that there is no formalised decision making process that measures the 'best fit' (ergo, best 'Value for Money') in a structured, calculated, and recordable manner, that is *specific to the facility in question*. VFM is essentially a default criteria option in the decision making process. Given Braunschweigs (2000) reductionist approach to generating the decision criteria, this necessarily provides a parameter for the decision-makers, which presents no conflict to the process. On the contrary, it provides a 'rule' in the context of the NHS and the refurbishment process. The Business Case process itself (of which the decision model seeks intervention points) is specifically identified within *Statement 7* of *CEL 35* (pp.3) in directing the NHS Bodies to ensure compliance with the Scottish Capital Investment Manual (Scottish Government 2010) in pursuing best VFM.

Although the CEL 35 policy is a high-level guidance document, it dictates the baseline for the structure of the PAMS. It is important to note the 'mandatory requirements' (pp.5 – 9) comprising of:

- Governance
- Strategic Asset Planning
- Acquisition and Disposal of Property
- Operation and Management
- Medical Equipment
- Performance Reporting
- General Statements

Re-emphasising the proviso that the Asset Management in the context of the research and the proposed model is concerned with the physical built assets and the infrastructure, not all of these requirements may be pertinent to the model. The next step is to review and critique the *Property Appraisal Guidance for NHS Scotland* (2010) Referring again to Figure 4.4.1b, this document can be identified in the hierarchal structure comprising the process in its entirety.

3.4.1.2 The Property and Asset Management Strategy (PAMS)

The *Property Appraisal Guidance for NHS Scotland* (2010) document may be viewed as the 'step down' link from the CEL 35 policy document (Figure 4.4.1b). As previously discussed, CEL 35 is a Scottish Government release and stipulates the high level recommended and mandatory guidance for Health Boards in preparing and monitoring their Asset Management strategies. It is important to understand from the outset, exactly what the scope of the guidance is, and as the name of the document implies, the focus is dedicated to the "estate as an asset" (HFS 2010 pp. 3) It is further noted (pp.4) that the property appraisal exercise (which forms the backbone of the ultimate PAMS creation) excludes 'other assets' such as furniture and fittings, IT equipment, transport related assets, and other portable equipment. Instead the main focus and required first step is the development of the *Property Asset Register*. The decision support model suggested by Wilson et al (2012) places the asset inventory as the first step in any potential decision-making process. This is the first identifiable integration opportunity between the requirements and processes of the PAMS, and the structure of the proposed model. A mandatory requirement of the CEL 35 policy, dictates that…

"Holding Bodies must utilise the NHS Scotland Asset Management System as a means of holding property and asset management data…" (ibid pp.5)

This feeds into the very reason for the PAMS existence and operation (platformed as described above by the construction of the Property Asset Register)

A discussion on the integration opportunities between the proposed model and the current PAMS/property appraisal requirements will be undertaken in the following section, however, there are characteristics within the appraisal guidance, which are standardized and bear remarking upon to provide suitable context. It is firstly useful to visualize the property appraisal process, and this will be useful in comparing against the information phase of the proposed model. Figure 3.4.1.2 shows a basic flow diagram of the suggested process.

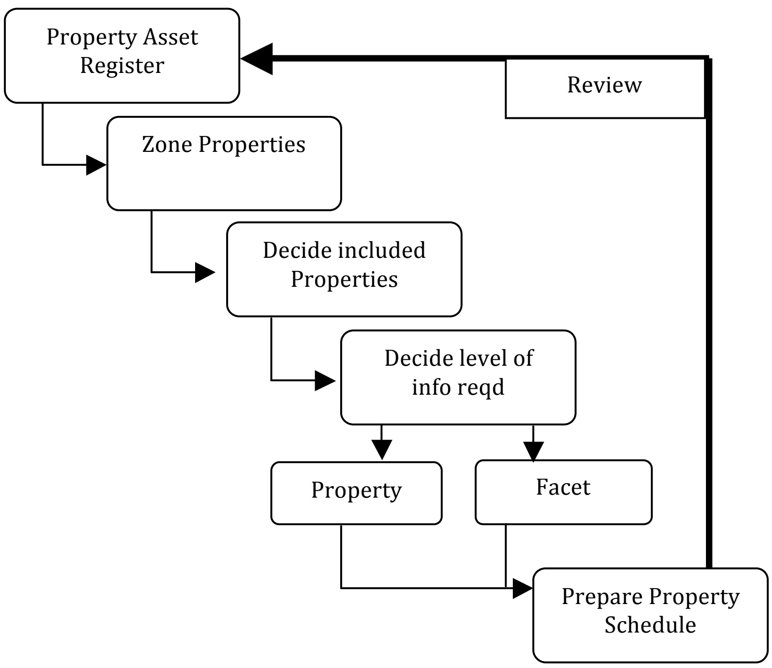


Figure 3.4.1.2: Summary diagram of the Property appraisal process (Adapted from HFS. 2010 pp.6)

Perhaps the most significant characteristic of the Property Appraisal process is the division of the activity/process into six distinct facets. These are:

1. Physical condition
2. Statutory compliance
3. Environmental management
4. Space utilisation
5. Functional suitability
6. Quality

The six facets identified above, are in essence, ready-made criterion identifiers, and as such will be positioned within the criteria selection process described in Chapter 6. These provide an excellent example of the transition from the mandatory requirements of criterion, to the preferential requirements which the decision making team may seek to include on a project by project basis.

Establishing Costs

The 'Establishment of Costs' of the property appraisal are also a key aspect of the process. In essence, the asset inventory will seek to quantify this as the 'Backlog Maintenance Cost'. Already, the system of 'facet separation' comes into play, as the backlog maintenance cost is derived from assessing the costs involved to upgrade the 'physical condition' (facet 1) to a level that is deemed satisfactory when considered against the ranking protocols within the guidance. In deriving the backlog maintenance cost, it is necessary to address any issues that are non-compliant within the statutory compliance facet. Although there is no ranking protocol for this facet, it seems self evident that there are only two possible outcomes in regards to statutory compliance, in as much as the asset or part of in question, is either legally compliant, or it is not.

Risk Assessment

The risk assessment section of the Property Appraisal process, is the actual transition of data collection and inventory findings, into the beginnings of a basic decision making process. A ‘consequence score’ and a ‘likelihood score’ are multiplied to derive a total ‘risk score’, which in turn are ranked to a linguistic assessment, such as Low, Moderate, Significant, and High Risk elements (respectively). Each risk outcome has additional guidance on the action that needs undertaken in regards to performance and legality.

Property Appraisal Guidance – Remaining Sections

The remaining sections within the guidance document consist of:

- Data Collection, Management and Reporting
- Performance Analysis
- Estate Investment Planning

These final three aspects, backed up by the more ‘mechanical’ or ‘doing’ activities described, are intended to provide the baseline for the PAMS of the individual Health Board. The data collection and performance analysis sections of the guidance are potentially powerful guidance sections for identifying and collating baseline data for criteria ranking and identification. The estate investment planning section should be read as a fairly high level statement of intentions or ambitions. It is interesting to note, that although there is no ranking protocol for the ‘Environmental Management’ facet, great emphasis is placed upon this very issue within the concluding section of the guidance (HFS 2010 pp. 35) Sustainability and carbon management are both noted as key issues, although it is unclear throughout the guidance just where and how these issues should be incorporated. Similarly, reference is made to ensure that…

“…a programme of works linked to an Environmental Management Plan…” (ibid pp. 35)

is included within the overall Estate Management Plan. The guidance statements in this instance however, seem much clearer and identify the requirement for an operating Environmental Management System (EMS), with the aim of working towards or achieving ISO 14001 accreditation. The EMS is discussed in detail within the literature review, and it is understood that there are no set requirements *as such*, and each board and its Senior Management will have made its own commitments and policy aspirations.

3.4.2 Integration Considerations within the Proposed Model

It has been demonstrated that the Property Appraisal process, and the myriad guidance documents and tools used in the planning, acquisition, operational management, and disposal phases of the process, operate on high to lower level basis. What is meant by this, is that the high level Scottish Government policy requirements, are the drivers for planning, and formalizing an asset inventory from a portfolio viewpoint, down to an understanding of an individual structure (or even element of a structure, dependent on scale) It has been discussed and noted from the literature, that an over-riding goal of the process is to ensure that best Value for Money has been achieved. This is in fact presented within the policy guidance as a 'duty' for NHS Scotland. The end result of the property appraisal process, in terms of the existing guidance, is the creation of a regional or board Property Asset Management Strategy (PAMS). The PAMS itself is the built asset aspect of the wider management strategy aims, and is intended as a means to allow for financial underpinning on the forward development of the service area in question.

In terms of decision making and understanding the financial, legal, and environmental implications of a given alternative, the risk based methodology set out in The *Property Appraisal Guidance for NHS Scotland* document (Health Facilities Scotland 2010) provides a simple yet effective system for ranking the different facets, and of deriving maintenance and/or refurbishment costs based on the backlog maintenance costs (Table 3.4.2). These costs may then be considered in regards to the criticality of the works been undertaken by again, utilizing a simplified ranking scale which calculates the potential consequence of the risk (or the effect of taking no action), against the likelihood that the risk will materialize (for example, the failure of services or plant systems).

Consequence Type	Consequence Score	Multiplier	Likelihood Type	Likelihood Score	Risk Score	Rank
Insignificant	1	x	Rare	1	tba	tba
Minor	2	x	Unlikely	2	tba	tba
Moderate	3	x	Possible	3	tba	tba
Major	4	x	Likely	4	tba	tba
Catastrophic	5	x	Certain	5	tba	tba

Table 3.4.2: demonstrates the calculation methodology for assigning a 'Risk Score' and therefore 'Risk Ranking' to the Backlog Maintenance issues of the built asset. (adapted from Health Facilities Scotland 2010 pp. 25)

As Table 3.4.2 demonstrates, the simple calculation process is carried out by assigning a consequence and likelihood score (respectively). It is accepted that these are subjective scorings on the face of it, however this does not mean that available quantitative data will not be used. On the contrary, this type of score finding may be far preferable, especially if considering a highly technical aspect such as plant or services. The two scores are simply multiplied to attain a calculated 'Risk score', which can then be categorized by rank. The level of actual Risk ranking is suggested within the guidance as being:

1 – 6 = Low risk

7 – 10 = Moderate Risk

11 – 15 = Significant Risk

16 – 25 = High risk

If (as is likely) the consequence and likelihood scores are not resultant from purely quantifiable data sources, then the experts, property assessor, or decision-makers subjective input must be used for the allocation of scores. There is an obvious aspect of decision-making undertaken throughout this process, but in terms of the decision-makers subjective input, this is concerned with ranking 'what exists', and identifying where the priority actions or works need to be undertaken. On this basis, the maximum expected output from the PAMS and the risk based methodology process, is a prioritized list of buildings, parts of building, elements, or components that require attention to firstly maintain, and secondly, improve the condition of the aspect in question.

What the PAMS et al does not provide in any structured or formalised manner, is a measured, weighted, and evaluated selection of 'best alternatives' for the facility (or part thereof) which takes the risk model described above, into a more detailed framework which has the flexibility to address the many idiosyncrasies (in regards to form, orientation, change of use, location, funding parameters etc.) that each structure, element or component set may have. It may even be argued that the identification and prioritisation of works is far from the end result, but conversely is the actual start point for the decision making process to begin. This point leads us to explore the integration opportunities (and utilities) of the proposed model, within the existing PAMS and estate management process. It is a mandatory requirement (CEL 35 pp. 5) that asset management data must be stored and available in a 'readily available and consistent' form. This is supported by the proposed models function, in that the platform is a commonly used software programme, capable of interaction and translation to most similarly based tools, including the Estates Manager ® tool developed by *3i Studio* which is the system used by NHS Scotland for its Property and Asset Management function.

Given the comment already made, that the output of the PAMS is essentially the beginning of the proposed decision making model, this can be visualized by comparison against 'Phase 1-Information' (Figure 3.4.2) This follows the 4 phase decision-making process suggested by Zavadskas et al (2008) consisting of (in phase order), Information/Decision Modeling/Solution selection/Implementation which will be demonstrated in detail in Chapter 6.

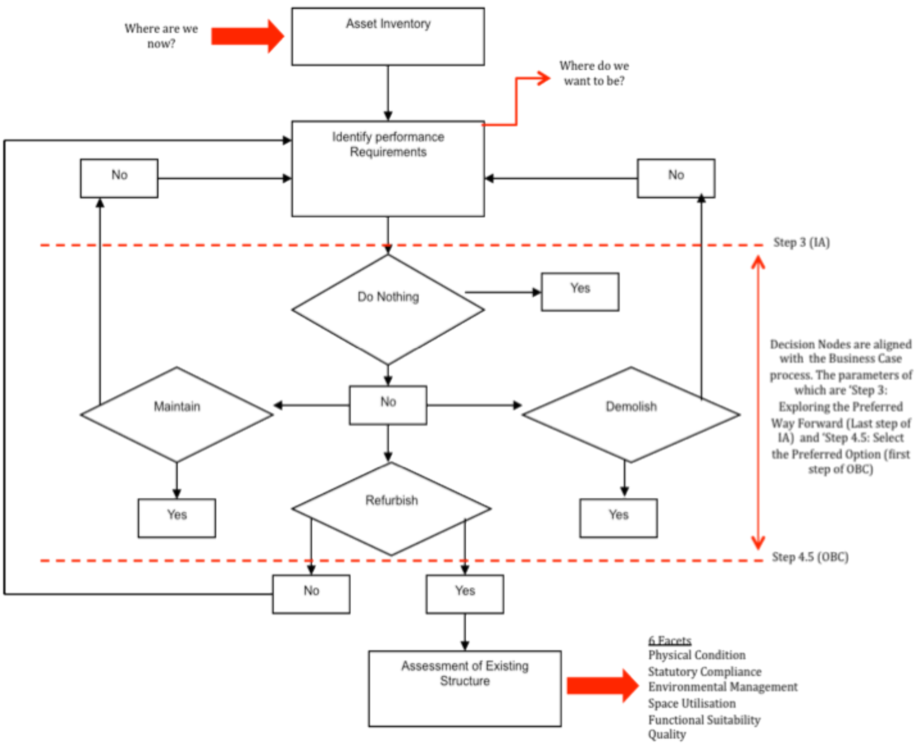


Figure 3.4.2: Basic integration points between the decision making model, the business case process and the property appraisal process.

The 'basic' integration points between the proposed model (phase 1), the business case process (as per the Scottish Capital Investment Manual) and the Property Appraisal guidance document, are shown in Figure 4.4.2. Attention is again called to the earlier observation, that it is the final phase of the Property appraisal process (in its current form) that leads into the Step 1 of the actual 5 Step decision making model. It is highlighted that the first two questions are addressed within this section of the process, from the three-question framework described within the PAMS manual, these being:

- Where are we now?
- Where do we want to be?
- How do we get there?

The third question of 'how do we get there? can be viewed on two levels. Firstly, and as per the commonly understood meaning within the PAMS, there is the strategic context. It is fair to say that the PAMS is by its very nature a strategic endeavor, and as demonstrated by the NHS Grampian PAMS (NHS

Grampian 2012 pp. 27-28) the aspirations for actions to be taken are separated in to the following high level areas:

- Public engagement
- Formulating health and healthcare plans to improve and modernize
- Innovative use of technology
- Governance and performance management
- Developing and maintaining the PAMS
- Implementation of the PAMS

It is proposed however, that this question/aim may also be applied to the proposed decision making process. 'How do we get there?' is stepped down to a more project focused level. The Property Appraisal Guidance for NHS Scotland document (Health facilities Scotland 2010 pp. 4) discusses the requirement for the preparation of a *Property Asset Register*. The type of property and the manner of splitting the portfolio for audit purposes is stated, as is the advice on sub-division of large properties if required. As can be seen from the property appraisal diagram process shown in Figure 3.4.1.2, there is a definitive step to identify the level of information (or detail) that is required from the appraisal. Detail expressed at an elemental or component level, as would be expected from the undertaking of a specific refurbishment or maintenance project, is ideal for analysis, ranking, and weighting throughout the proposed decision making process at facility level. In essence then, although the PAMS itself expresses the question of how to attain the identified targets or goals in high level and strategic terms, the risk based methodology offered by *Health Facilities Scotland* in the appraisal guidance, does in fact validate and support the need and utility of a decision making model which is applicable at the level of individual building or part thereof.

CHAPTER FOUR   RESEARCH METHODOLOGY

4.0 Introduction

The research methodology can also be considered as the overall *research strategy*. Hall and Hall (1996) and Holt (1998) describe it as the 'overall method' with which to satisfy the key aims of the research project or investigation. Fellows and Liu (1997) define the research methodology as the logical thought processes, which are associated with the investigative process. The objective of this is to construct a theoretical framework, on which to apply the principles and procedures necessary for a successful research outcome. A later edition by the same authors (ibid 2008) offers the analogy that this *theoretical framework* provides the same structural support and integrity, as a steel or concrete frame, provides on a construction project. In regards to the doctoral research, it is commonly accepted that one of the key objectives of the process overall, is for the researcher to demonstrate an understanding of the philosophical processes and, through application to the research question, a working competence relative to a real-life project. This is evidenced in definitive terms by the *Quality Assurance Agency in Higher Education* (QAA) whose requirement descriptors for a doctoral degree (QAA, 2008) state that successful candidates must have demonstrated…

"A detailed understanding of applicable techniques for research and advanced academic enquiry"

This is supported more subjectively throughout the relevant literature by scholars in the field, such as Greenfield (2002) who proposes that a successful researcher should demonstrate skills of inquiry, data collection techniques, and the ability to analyse the results. Grix (2001) recognises however, that the doctoral process is in effect 'an apprenticeship' in the art of research, with a key objective of being able to demonstrate the 'meshing' of theory and practice.

Chapter Outline

This chapter explores and demonstrates the research methods and methodology used throughout the research project. The overarching framework of the research design is shown, and the research questions presented in Chapter 1, and signposted throughout the literature review, and contextual background chapters, are positioned in the context of the methodology used. A triangulated approach has been used at all levels of the methodological development, and this is clearly illustrated in the context of the quantitative and qualitative data collection requirements and processes, the identification of a reasoned and logical sample frame, and in the main primary data collection activities which have been developed to satisfy the objectives of the wider research.

4.1 Design of the Research Framework

This section of the chapter will discuss the specific *design frame* used within the research project in greater detail. Using Sutrisnas (2009) 3 dimensional groupings of the over-arching methodology, the chapter will address the following three points.

1. Identify and justify the philosophical stance of the research
2. Identify and justify the logical reasoning behind the research
3. Identify and justify the data collection types.

The specific research methods associated with the above three points will be placed and discussed throughout. As a starting point however, Figure 4.1 shows the conceptual design frame related specifically to the research project.

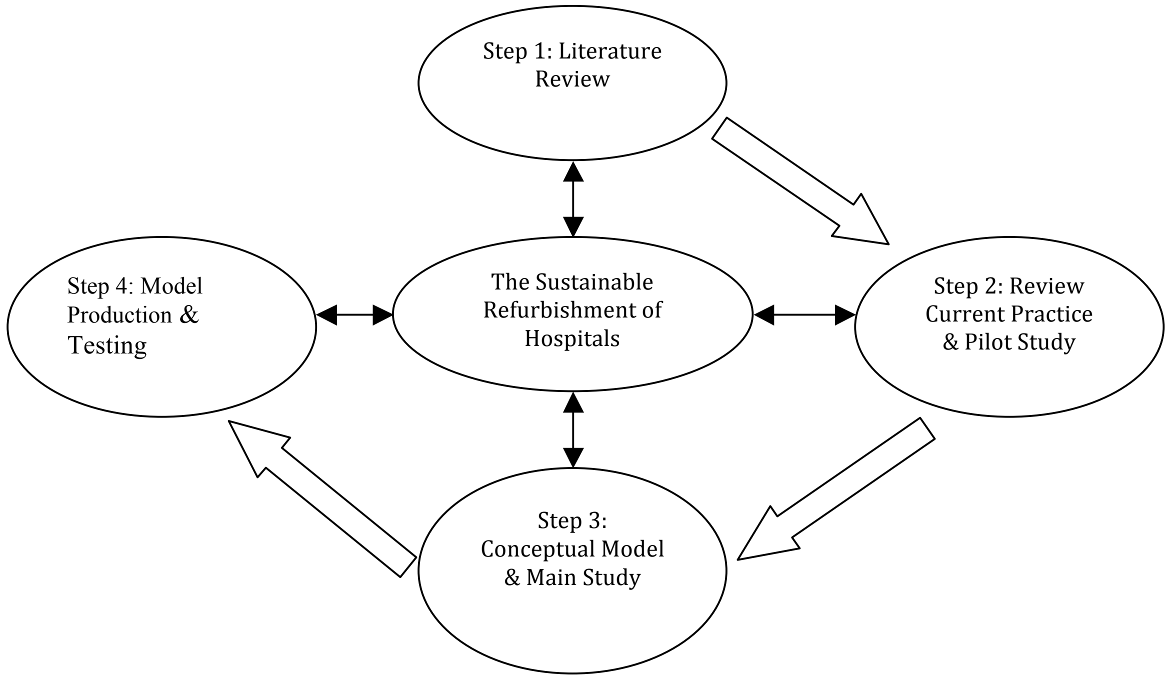


Figure 4.1. The methodological design frame (adapted from Maxwell 2005)

4.1.1 The Philosophical Stance

A mixed methods approach will be employed throughout, however, given the nature of the research area, a completely deductive approach is not suitable. Although, by a process of in-depth literature review the dominant reasoning of the research has indeed been of a deductive nature. However, it is not enough to see only 'the gaps' and attempt to construct the research question around them. By means of informal communication, ad hoc interviews, and critical reflection, the inductive reasoning approach has also been crucial to 'joining up the dots' and to support the introduction new concepts and/or questions to the design frame.

The deductive/inductive 'reasoning' positions are actually better placed in the following section (*reasoning of the research)* however, it is considered as virtually impossible to separate them completely from the philosophical stance. The research process in this regard is far from clear-cut. This can be more clearly understood by considering Sutrisnas (2009) observation that although a key requirement of the research (and doctoral) process, is to identify and describe the researchers philosophical viewpoint (and view of the world), the nature of the research project may dictate that a dogmatic stance by the researcher may not be possible. The dangers of hypocrisy and inconsistency are highlighted, and yet there is no hard and fast rule which prohibits the researcher from changing their perception.

Figure 4.1.1 illustrates the ontological and epistemological paradigms in relation to the specifics of the research project.

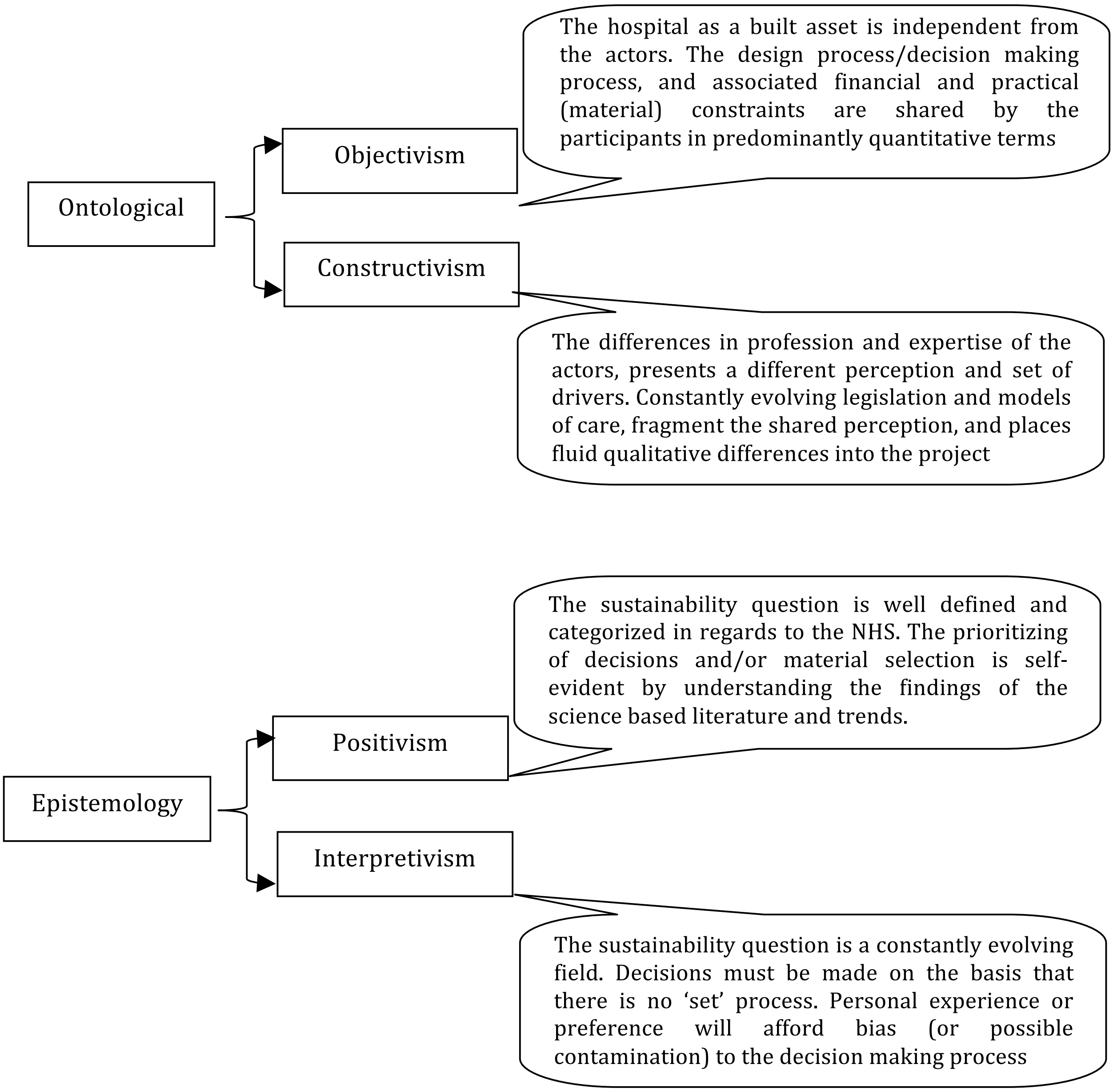


Figure 4.1.1. The ontological/epistemological approaches relevant to the research project. Mixed method considerations are shown

The ontological and epistemological considerations demonstrated in Figure 4.1.1 show the issues (challenges?) from the *perspective of the research participants/actors.* This may seem to contradict the requirement for the researcher to reflect upon and develop the philosophical stance, and yet, the issues shown (of which these must be seen as examples only, and not the full range of theoretical drivers) reflect and mirror the over-arching research methodology. In essence, the research methodology has been partly shaped by the research matter and the characteristics of the intended sample frame and associated stakeholders.

Exploring this 'evolutionary' process of positioning the research methodology, in greater detail, the main facets of the overall project must be examined. To this end, and given the nature of the hospital as a functioning built asset, the multi-disciplinary composition of the main actors, and the multi-faceted characteristics of the issue of sustainability; it has only been possible to explore and derive the research questions by accepting aspects of all of the above research philosophies, albeit in different degrees of dominance. The use of induction is a constantly evolving exploration of the 'state of the art', and has directed the researcher to undertake subsequent deductive, literature, and fact based research, based upon the findings. The research, 'mixed methods loop' is completed, by the requirement to undertake further inductive inquiry, based on the quantitatively based findings…and so on.

4.1.1.1 The Research Questions

Two main research questions have been identified. Below each is a range of sub-questions which must be answered as part of the process.

Question 1

Is there a requirement for a decision support model for undertaking sustainable refurbishment of hospital and healthcare buildings?

G. Do current tools and processes identify areas of priority in identifying key decision making criteria?
H. Do current tools and processes offer a best option, or alternative for the project, based on 'project specific' criteria?

I. Is there a formalised management/facilitation process, that ensures that a rigorous and demonstrable decision making process has been undertaken? (within the mandatory institutional requirement to demonstrate Value for Money)

Question 2

Are Multi Criteria Decision Making techniques applicable to the undertaking of sustainable refurbishment of hospitals and healthcare facilities?

J. What is the level of knowledge and application of MCDM techniques from within the main actor groups?
K. Are MCDM techniques compatible with the existing systems and processes used within the NHS/Design teams?
L. Can the use of MCDM modeling techniques, demonstrate that Value for Money has been achieved as far as reasonably practicable, specific to the project in question?

4.1.2 Reasoning of the Research

A key dimension of the research methodology predominantly comprises of both the *deductive* and *inductive* approaches. It is highlighted that the research project has demanded, by its very nature, that a mixed methods approach is undertaken.

Figure 4.1.2a illustrates the triangulation/mixed methods approach specifically in relation to the research project.

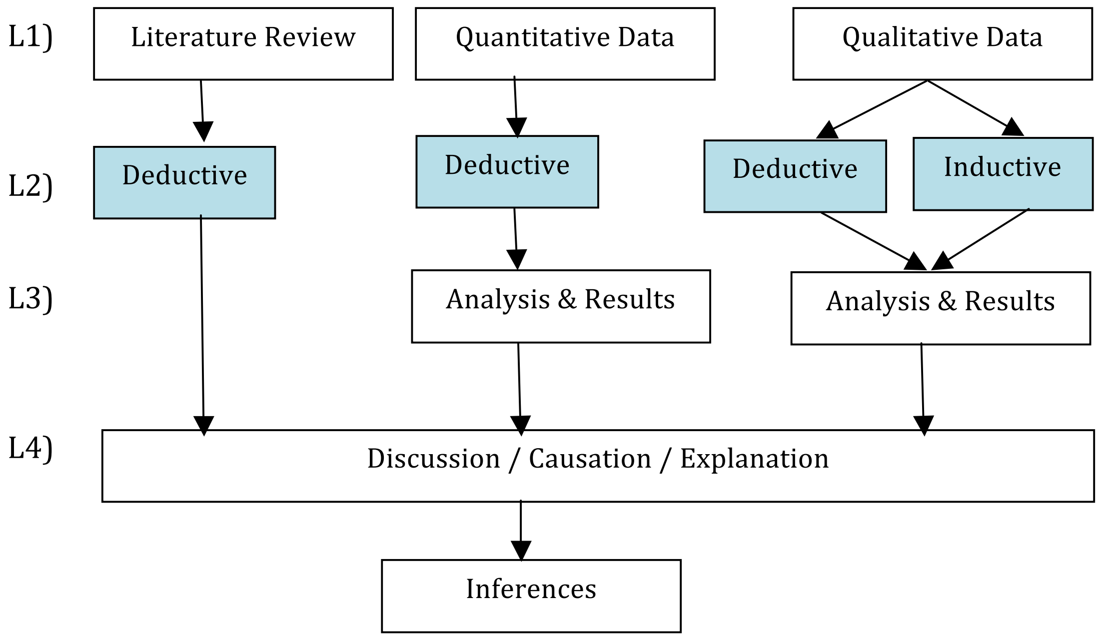


Figure 4.1.2a. The use of deductive and inductive inquiry shown in Layer 2 (L2) within the projects triangulated (mixed methods) approach

What Figure 4.1.2a illustrates is the conceptual positioning of the deductive and inductive approaches in relation to the mixed methods approach of the research design. In practical terms however, how have these actually been applied?

Introduction of the Research Methods

Sutrisna (2009) identified the component parts of the research methodology (the research 'methods') as 'merely tools'. Relevant to the mixed methods (triangulated) approach shown in Figure 4.1.2a, the research methods employed will be described in greater detail, and relevant to the research project specifically. Figure 4.1.2a also separates the triangulation process into distinct layers, designated with the relevant prefix i.e. L1 = Layer 1. The layered approach has been used, as there are research methods used for specific purposes, dependent upon the inquiry method, and also data source.

The Literature Review

The literature review (Figure 4.1.2a: L1) is an essential part of the doctoral and research process. It is also a recognised method with which to underpin the entire research area. The first stage of constructing the literature review, necessitated that the main aims and objectives of the research could be broken down into their component parts. This process of 'deconstruction' provided the essential step in the 'refining process' which took the initial subject idea, through a narrowing down, or funneling, process to identify the specific topic. Figure 4.1.2b illustrates this process.

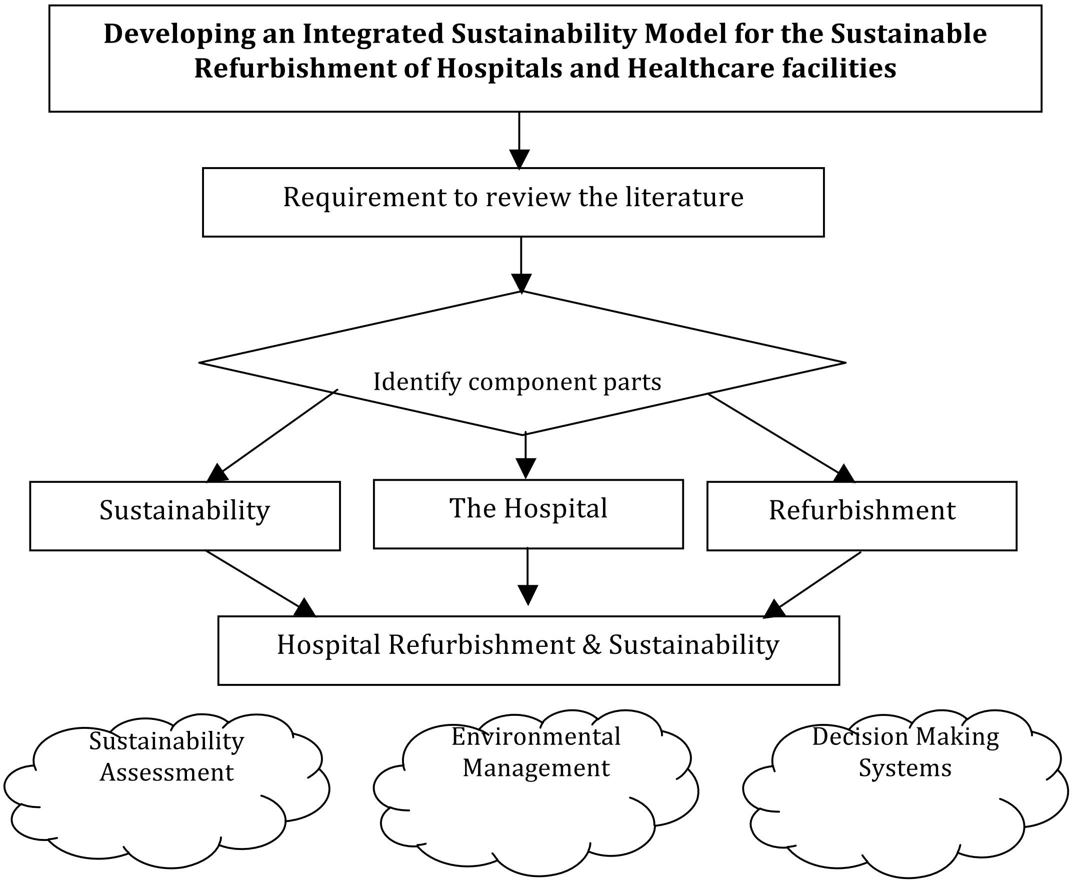


Figure 4.1.2b. Deconstructing the Literature Review as a research method

Loose (1993) suggested that the process of deductive research must begin with the conceptual and theoretical structure must first be visualized before any empirical testing or observation can commence. Figure 4.1.2b demonstrates how this has been achieved within the research project. The sections exploring sustainability assessment, environmental management, and decision-making systems are the direct deductive result of a rigorous and focused review of the core (mandatory) aspects of the research aims and objectives.

The Quantitative and the Qualitative Data

Although the quantitative and qualitative approaches have been identified as separate 'angles' of the triangulation model shown in Figure 4.1.2a, the research methods selected for the project fuse both approaches within the tools that are used. Given the nature of the subject area, and beneath the umbrella of 'social science', this is recognised not only as a 'preferable' method, but as an 'essential' one. On the understanding that this is the case, the focus for differentiation of data types, moves to the identification and collection of *primary* and *secondary* data. It is re-emphasized that both of these data sources are a hybrid mix of quantitative and qualitative attributes.

The Secondary Data

The secondary data is comprised almost entirely from the results of the literature review. It has provided an essential foundation for the research design (Figure 4.1.2b) and by its nature has taken a wholly deductive approach. It may be argued that the study of the literature has identified subject areas in isolation (such as decision making processes), and as such, demonstrates an inductive characteristic in steering the research requirements, however, this is discounted within the research as being more associated with the process of *emergent findings*. The true heart of the quantitative/qualitative, and the deductive/inductive mixed method approach, is demonstrated in the design frame by the identification and collection of the primary data.

The Primary Data

The primary data is identified as the data which has been collected by the researcher himself. The triangulation model is again referred to, and the data requirements have necessitated both quantitative and qualitative data collection. A range of methods have been employed in the collection of the primary data, including, questionnaires, group seminar discussion, telephone conversation, and ad-hoc meeting/interview processes. The main objective of the primary data collection has been to verify the findings of the secondary data collection process (i.e literature review), and to elicit enough information to inform the developmental requirements of the prototype model. So that the research findings provide a 'narrow and deep' understanding of the specific research area (especially in the context of the main questionnaire and the ad-hoc interviews) it has been essential to identify and design a specific set of instruments and methods in regard to the *population sample*. The population sample itself, is situated as a dimension of the over-arching protocols associated with the *sample frame*.

The Sample Frame

The literature review was instrumental in identifying the population sample. The recognition of processes and actors from the reviews findings provided (by deductive means) the required amount of information to allow the composition of the main research questions shown earlier in this section. As a natural progression from the development of the research questions, a select group of experts and professional disciplines was also identified. Given these characteristics, the sample methods used were directed to the activity of *non-random sampling*. The non-random approach is clearly dictated by the fact that only a specifically targeted group of individuals were admissible as sample participants. Creswell (1998) discusses the activity of purposeful sampling, and yet still identifies a wide range of sampling methods, dependent upon the purpose of use. The research identified that a hybrid design incorporating the *stratified purposeful* and the *criterion sampling* approaches was most justified.

The 'stratified purposeful' approach is key in the context of the research, as it is understood that the optimum scenario in regards to both timing and stakeholder engagement lays in the initial financial and technical appraisal processes. Given the over-riding factor of the public purses requirement to achieve best 'value for money', this places the early decision making opportunities within the realm of the expert professionals. This supports the second methodology of 'criterion sampling' which demands that the study population achieve a minimum standard of professional knowledge and/or experience, which, in effect, is the qualification gateway for the respondents participation.

The secondary data collection methods have been illustrated in Figure 4.1.2a. Figure 4.1.2c focuses on the primary data collection design. It is significant to note, that although Figure 4.1.2c shows the design and the placement of the research methods in a multi-faceted (or triangulated) approach; the 'type' of data collected within each method are also comprised of a mixed method approach. Both quantitative and qualitative data have been collected within each of the methods shown. This has either been by deliberate design (as per the considered structure of the questionnaire processes), or naturally occurring (as per the direction taken throughout the group seminar or ad-hoc meetings) Deductive and inductive approaches can also be observed within these 2 main approaches, as on the one hand, the quantitative design seeks to deliberately explore a subject area (or areas), whereas the qualitative data gleaned through the more informal collection methods, has taken the researcher and the research question on an uncharted (and potentially) more creative route.

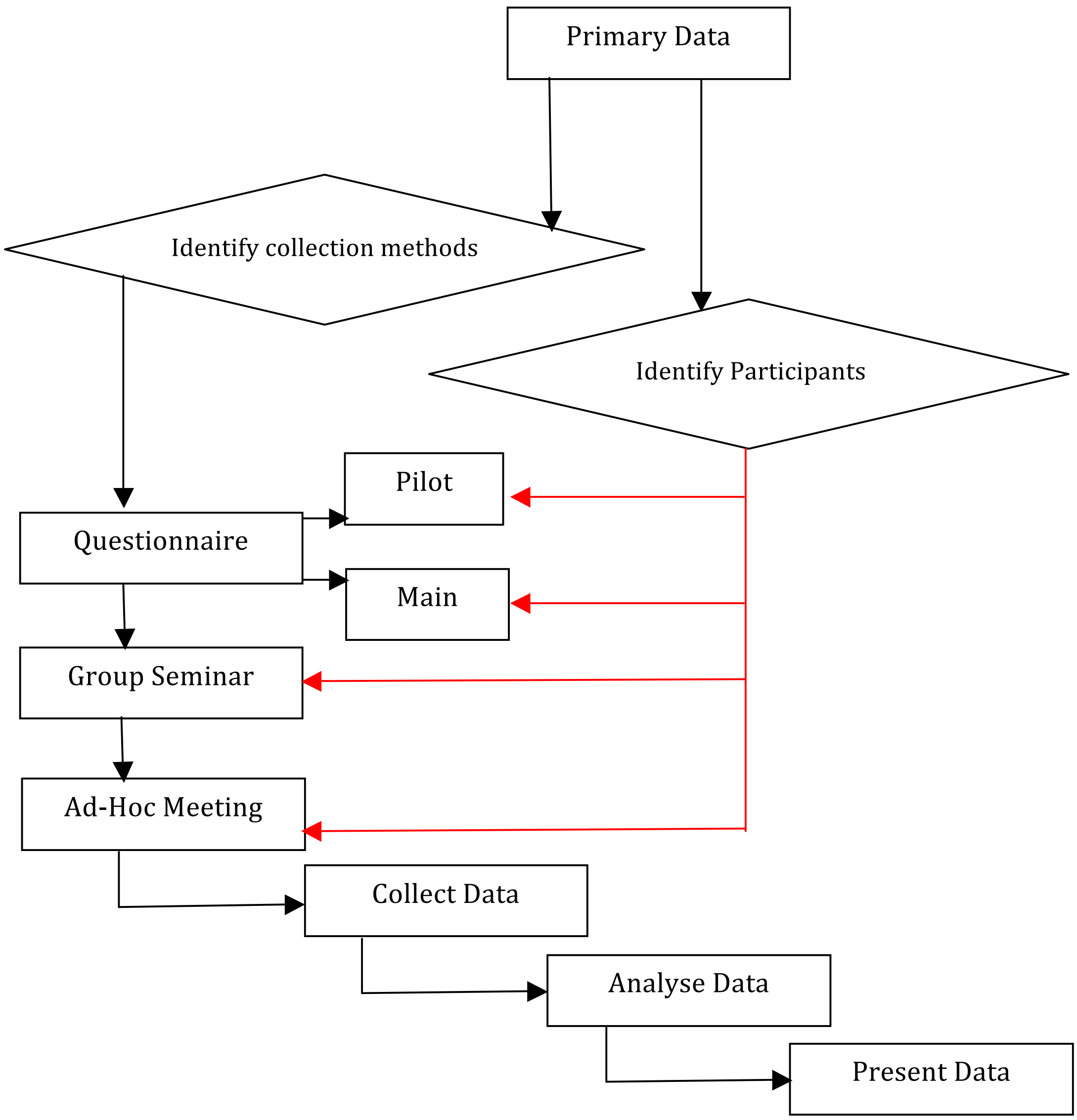


Figure 4.1.2c. The design of the Primary Data collection

4.1.3 Data Requirements

The third and final component of Sutrisnas (2009) three-dimensional approach to research methodology are the *data requirements*. In large part, these have already been discussed within the previous two dimensions in this section, but for clarity, it is reiterated that on the 'data level', the characteristics of all the data requirements for the project fall into the main two categories of quantitative and qualitative types.

With reference to the previous section and with the research design shown in Figure 4.1.2c, it is instructive to view the questionnaire templates designed for the primary data collection.

4.1.3.1 The Pilot Study

Although the pilot study is not a mandatory requirement of the research (or doctoral) process, it is nevertheless an effective and valuable tool in the research methods box. Thomas (2009) presents the simple explanation that it is a means by which a smaller version of the main questionnaire is trialed, in preparation for the larger (main) activity. Fellows and Liu (2008) provide stronger justification in stating that…

"All questionnaires 'should' be piloted initially…"

There are multiple practical reasons for undertaking the pilot study, but the main benefits are seen in the opportunity of testing out the format and logic of the questions being asked. Questionnaires are notoriously unreliable in regards to the number of responses collected. This was a key consideration for the project, given that the non-random population sample was far more targeted (and therefore smaller) than a broad-brush random sample. To this end, the researcher was very aware that the main survey was presented in a format that was uncomplicated and intuitive to complete, and also to ensure that the questionnaire (and therefore research) retained credibility by posing intelligent and logical questions. Again, given the deliberate targeting of experts and discipline professionals, it was considered essential that the questions asked were pitched at 'just the right level', to ensure response, and collection of the required data.

One of the key challenges in constructing the pilot, was the identification of the population sample. It had already been ascertained that this was non-random sample, employing a hybrid method of 'stratified purposeful' and 'criterion sampling', however, this still did not identify specific professional groupings. The decision on how to identify and group the respondents was derived mainly from the secondary data collection carried out as part of the literature review, however, the process of ad-hoc meetings and discussions also allowed the researcher to stratify the respondents based upon a process of neutral observation. This in turn reflects the researchers quantitative approach to this identification process, and is supported by the objectivist, positivist, and deductive approaches.

Based on the above methodology and thought processes, a population sample was identified based on two main criteria. These criteria were reflected upon as being the 'professional strata' itself, and also the 'characteristics' of the chosen strata. This method was deemed most suitable, as the vast range of individual professional disciplines related to the NHS and also the Design Teams and Principal Supply Chain Partners would have created an impractical number of respondent groups. Given the non-random (and therefore relatively small) number of respondents overall, it was reasoned that this over-fragmentation, would present difficulties in analysis and inference. Table 4.1.3.1 illustrates the method used in categorizing the pilots population sample.

Professional Strata	Sample Characteristics
Healthcare Professional	Client / Clinician
Design Team Professional	Designer / Constructor
Sustainability Professional	Consultant
Academic Professional	Researcher

Table 4.1.3.1. Sampling methodology for the pilot study

A main difference between the pilot and the main questionnaire, was the provision of a comments/feedback box after every question. The respondents were encouraged to be critical of the preceding question, and to provide recommendations. A main 'overall feedback' box was provided at the end of the pilot, to capture overall impressions and/or make comment on any issues that had not been covered within the survey.

4.1.3.2 The Main Questionnaire

The main questionnaire is arguably the most central primary data collection method employed within the projects research design. Following on from the previous section discussing the pilot study, the feedback gained was of immense value in developing the finished product. Aside from feedback relating to ambiguity, format, and relevance of the pilot, the most significant effects on the design of the main questionnaire were in the areas population sample, and level of 'technical pitch'.

In regards to the actual presentation of the questionnaire, the feedback was highly critical of the software platform used. As a free application, the survey form itself was peppered with advertising icons, many of which were dynamic and flashing. This was universally considered as very irritating to the respondent and gave the survey a non-academic or unprofessional feel. The population sample was modified for the main questionnaire. This was based on the grouped responses and comments from the pilot, and supported by the ongoing review of the literature and ad-hoc discussions. Table 4.1.3.2 shows the modified population sample.

Professional Strata	Sample Characteristics
NHS Management	Estates and Facilities
NHS Management	Asset Management
NHS Management	General
Principal Supply Chain Partner	Architect
Principal Supply Chain Partner	Engineer
Principal Supply Chain Partner	Contractor
Other (Please specify)	n/a

Table 4.1.3.2. Population sample for the main questionnaire (modified groupings)

4.1.3.3 Limitations to the Questionnaires

Both questionnaires were subject to practical limitations. The over-riding demand for these limitations was the scope of the research project itself, and the associated time and resource limitations involved. What is most noticeable is the composition of the population sample surveyed. Justification has been given on the identification and selection of a non-random target group of professionals and yet, given the functional requirements, and the social positioning of the hospital, and the NHS as a service, the question may be asked of 'where is the general public and the service user?'

The decision to omit the general public (both patients and visitors) is based on the findings of the secondary data collected within the literature review, and considered against the main aims and objectives of the project overall. This includes the relevance of these user groups in addressing the main research questions. As the composition of the questionnaires demonstrate, the data requirements are predominantly technical in nature, or related to discipline specific guidance documents and systems. In general terms this entails a rigorous study of the planning, design, construction, and overall business case processes uitlised in the refurbishment activity related to hospitals. This echoes the earlier observation, that the research project is intended to investigate a 'narrow and deep' area, which is by nature, highly specialized.

It is accepted that the focus on professionals does not encompass the full sustainability model, and especially in regards to the criteria such as (but not limited to) *community*, and *health and well-being*, there seems an obvious conflict. Following criticism and observations from the pilot, and the defence of papers published for conferences (respectively), the main questionnaire was expanded to take cognizance of the user groups, even if they were not engaged directly. The purpose of this expansion was two-fold. On the one hand, the researcher sought to justify the 'non-inclusive' method adopted. On the other hand, and if failing to present such justification, the researcher sought to provide self-critical evidence of a gap in the overall research design.

It is reiterated however, that the targeted decision makers, and the envisaged intervention point of the model in the appraisal process supports this approach. The inclusion of legal and technical guidance and documentation has been limited to the most commonly used, as supported by the literature review and secondary data collection. The main criteria are taken from the Department of Health's own guidance. These criteria are focused on the planning, design, construction, and operation of a healthcare facility, and do not take account of the far wider sustainability agenda, and as such are representative of sustainability in this context only. The over-arching appraisal and procurement processes have been restricted to the study populations experience with the *HM Treasury Green Book*, the *Office of Government Commerce* (OGC) Gateway process (although recognised as archived), and the *Scottish Capital Investment Manual* (SCIM). This approach has limited the surveys appreciation of the relationship and connectivity's to the various Public Private Partnering arrangements.

4.2 Illustrating the Research Process

The entire research process is a connected and inter-dependent activity. The details and mechanics of this have been presented within this chapter, however it is instructive to illustrate the process, showing the key activities and the connectivity's referred to above. Figure 4.2 demonstrates the holistic methodological process, which has been undertaken. An outline structure of the methodological design is demonstrated, showing key activities and deliverables of the evolving model. This is linked into the research design frame illustrated earlier in Figure 4.1. The research activities, in regards to engaging sample frames and testing groups, are clearly shown. The feedback loops indicate the iterative nature of this aspect of the prototype design, which was informed and influenced by the ongoing findings of the research and design process.

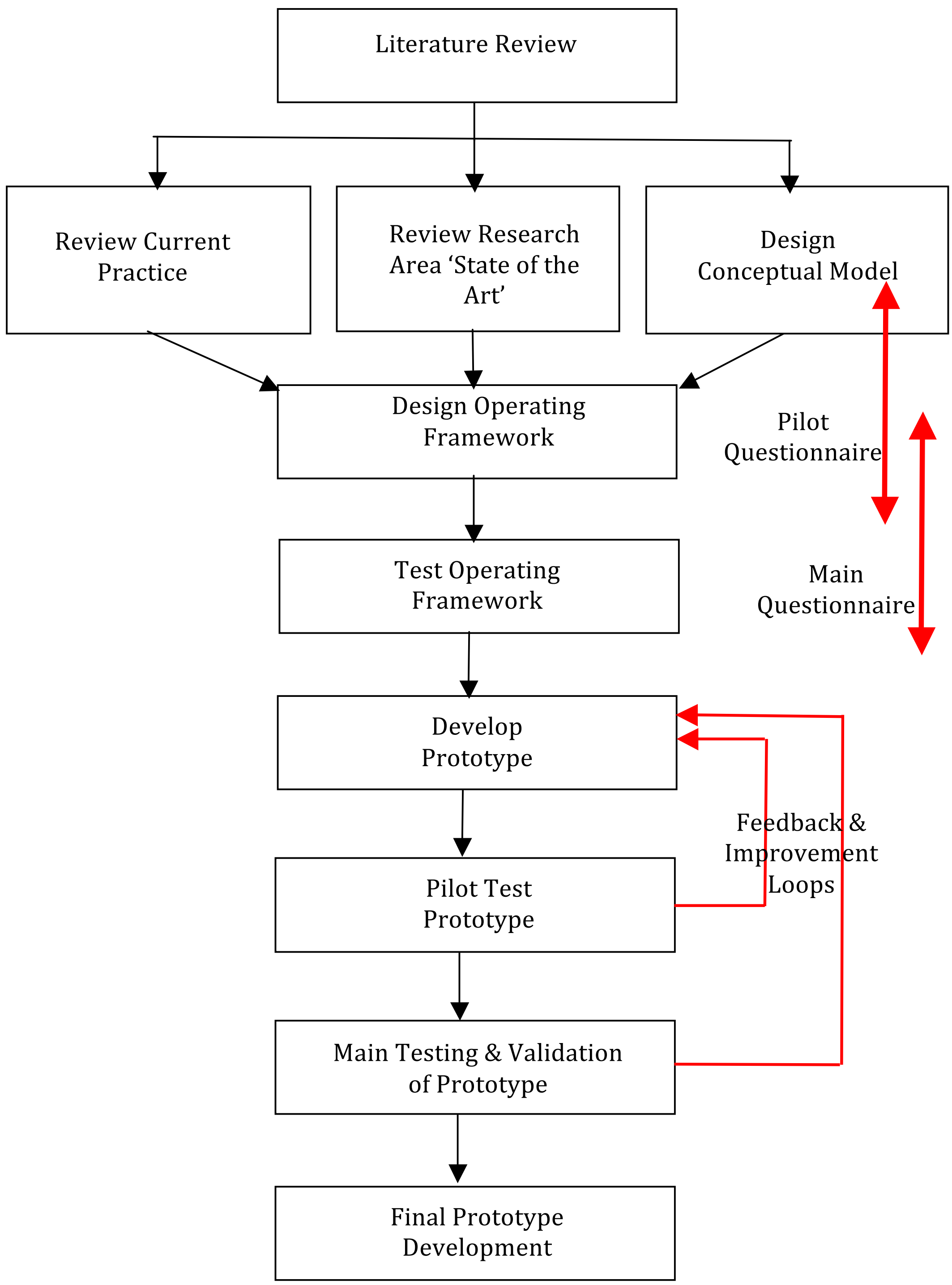


Figure 4.2. Summary Methodological process of the Prototype design

4.3 Validity and Credibility

Despite the identified limitations discussed above, it is critical to present the research methodology (and the methods contained therein) in a manner which justifies and supports the validity of the process, and the credibility of the overall research approach. It is interesting to note McBurneys (1998) comments, that the perfect experiment or design does not in fact exist. This is by no means interpreted as a negative aspect, and indeed, encourages the researcher to be creative in the context of their own research. The methodology chapter presented here is intended to provide sufficient information to demonstrate that a wide enough, yet focused approach, has been undertaken in constructing the research design. This is identified as 'good practice' by Robson (2011) and the triangulated approach to data identification and collection, which are explored and discussed throughout this chapter, support this. The validity of the methodological approach therefore, is very closely aligned with the credibility of the research project overall. Sutrisna (2009) defines credibility as being demonstrated through characteristics (or qualities) such as rigour, thoroughness, and appropriateness. The methodology chapter presented here, has been constructed from a high-level approach, exploring the philosophical underpinnings of the research direction, and carefully broken this down into very subject specific layers of design. In identifying the sample frame especially, the methodological approach has deliberately taken the step from the conceptual philosophical needs of the project, into the area of engaging 'real world' experts and practitioners. This follows the over-riding ethos of the researchers approach, in maintaining focus on the fact that the main objective or output for the completed project, is a practically accessible, and industrially relevant working prototype to support, facilitate, and guide the decision making process, as undertaken by the actors identified within this chapters sample frame.

4.4 Ethical Considerations of the Research

It is important from the outset, to define what this section actually seeks to discuss when entering into the area of ethics. The research subject area is multi-faceted, in the sense that it crosses industrial disciplines and roles, but in the context of the hospital and healthcare facility. When dealing with any aspect of healthcare, it is therefore a default position that ethical considerations are given absolute priority before moving forward with the research design. It is noted however, that in the context of the research, ethical considerations themselves, may be separated into two main groups. Greenfield (2002) separates the ethical aspects, as being those of an inherently 'moral' nature, as in areas which would encroach upon personal values and beliefs (stem cell research may be a good example), but also into ethical considerations of the research process itself. These ethical questions are more pragmatic for the researcher, and focuses more on the quality and execution of the research design, and the integrity and honesty of the analysis process, and subsequently the reporting of the results.

In the context of the research project, this required a great deal of thought and reflection, and understanding what exactly the research questions, and the projects aims and objectives were intended to be, was critical in shaping the ethical approach. The nature of the business case process, and the key intervention opportunity for the developed prototype, were both guiding factors in the identification of the population sample and envisaged end users of the model. The process of critical reflection referred to above, was strongly supported by active engagement with NHS and PSCP management professionals on a frequent and ad hoc basis. It was considered as a fundamental priority to 'test' the reaction and response form the industry practitioners, as to their willingness to participate, given their already demanding time constraints. To this end, a dominantly practical or 'green grass' approach, was identified *from the practitioners*, as being more likely to succeed, as opposed to a more philosophical, or 'blue sky' approach. There were numerous 'tacit' concerns which were viewed as critical to appreciate, in selection and engagement of the sample frame. Communication and hierarchy 'norms' had to be identified and approached with a great deal of care. Although these (often socially based) ranking, discipline, or hierarchical interfaces, are not recorded as such in any contract, scope of works, or job description; it was nevertheless the case that engaging individuals without careful thought on how this might be viewed from their peers or potential superiors, may have placed the individual in question in a potential embarrassing or uncomfortable situation. It was considered absolutely critical, in addition to wholly ethical, that this scenario was avoided at all costs.

It was a concern in the early stages of the project, that interfacing with the general public (and especially the patient population) would present ethical issues which would present a risk factor to the project in terms of permissions, resource, and time horizons. The literature review, and the early primary data collection, by means of ad hoc interviews and communication with the clinical and PSCP professionals, quickly revealed that given the nature of the models intended use, there was in fact no opportunity, nor requirement, for the public to be involved with the primary research process going forward. This was confirmed through the pilot study and the main questionnaire which was distributed to both clinical and PSCP professionals alike.

The final main point in regards to the ethical considerations adhered to throughout, is discussed in the context of the demonstration workshops undertaken with the NHS/PSCPs as the requirement to test and validate the prototype. As can be seen in the model development chapter, the functioning prototype has been presented in the context of a real life case study. Full permissions to do this were obtained in writing from the relevant Health Board, and where final options have been identified; these have been changed to show options A, B, C, D etc., to remove any proprietary identification. The ongoing discussions with NHS managers and PSCP professionals, sought to design out any extraneous or superfluous aspects of the prototype before testing and validation, and conversely, to identify any aspects which might need modified or added. The relevant managers and professionals were assured that any suggestions or comments on the models development, which were related to their own experience of live projects, would be recorded with absolute confidentiality and anonymity. Similarly, in the testing and validation phase, which is described in detail in chapter 7, as a prelude to the actual testing workshops, and the validation feedback, an informal discussion was initiated with the participants, to provide assurance and parameters on any comments of feedback they may have. It was clarified that the researcher was open to any degree of criticism or input that the testing groups felt from the workshop sessions. To this end, the experience and motivation of the researcher himself was discussed, and each workshop group was made to feel entirely comfortable with providing objective critical feedback, free from any bias.

4.5 Chapter Summary

This chapter has presented a structured and detailed discussion and illustration of the over-arching methodology. The following key points have been addressed:

- The nature and relationships of the research *methodology*, and research *methods* has been illustrated.
- The selected methodology for the research has been presented and justified, showing the mixed methods approach to the research design and the data collection techniques.
- The main research questions have been shown, which have evolved throughout the literature review process discussed in chapter 2.
- The structured design of the primary data collection phase has been shown, including the process and timings related to the identified participants.
- Data requirements have been identified which have supported the shaping and construction of the pilot and main survey questionnaires.
- Clear limitations to the questionnaires and the selection of sample frame were discussed, with supporting justification of the participants which were finally identified.
- The validity of the research design and the selection process was presented, which in turn supports the credibility of research purpose.
- There were a number of mandatory, and subject area specific, ethical considerations, which were identified as critical to the management and success of the project. A key consideration in this context, was managing the disparate, yet intrinsically connected, professional disciplines, and taking great care in ensuring that communicating and engaging with the participants, was carried out in a sensitive and appropriate manner.

CHAPTER FIVE RESULTS AND ANALYSIS

5.0 Introduction

The purpose of this chapter is twofold. The first objective, is to present the findings of the primary data. Integrated within the results themselves, the primary data will also be analysed in the context of the main research questions. This method of constructing the chapter necessitated critical reflection on deciding what the most effective and efficient means would be for communicating the data collected. It is reiterated, that this again, is subject to the results relevance in the context of the main research questions.

The Methodology chapter identified a mixed-methods approach to the research, but recognised the dominant use of quantitative and positivistic approaches. Brewer (2007) identifies this as a key observation in the results presentation, and recommends the use of tables and figures as best suited for quantitative and positivistic purposes. To identify the most effective means of doing this however, a further two considerations were deemed as critical, and a rationale required for both. These considerations were:

1. What depth of filtering is required for the population samples responses?
2. What level of complexity and related statistical presentation is required to present the findings?

The rationale for each of these considerations is discussed in turn.

5.1 Filter Depth of the Data

As shown in Figure 5.1 (the sample frame has been grouped into seven main disciplines. Three of these capturing the actors from the NHS management side, three capturing the main participants of the standard design team, and an 'other' category to place consultants or participants out with these categories. The main research questions, and the sub-questions within them, focus on the model, the processes, and the decision-making techniques of the 'integrated team' within the standard business case process. It is re-emphasized that the focus is on *the model* development, and not on separate studies of individual disciplines and their individual knowledge base. This is identified as both a limitation to the study, in terms of the level of detail applicable to the research aims, and also as a recommendation for further research, *if* the overall conclusions of the research project deem it necessary or useful. To this end, the data has been filtered to present the findings of the entire sample frame as the integrated team, and not presented by 'discipline'.

5.2 Statistical Presentation and the Sample Frame

Although seemingly at odds with the dominance of quantitative and positivistic methods, as described previously, the majority of the questions within the main questionnaire are presented as *categorical* data. Gray (2004) makes the point that categorical data cannot be quantified numerically, but placed and ranked into the data 'categories' of *nominal* and *ordinal* characteristics. The structure of the questions and responses throughout the findings demonstrate a mix of both nominal and ordinal data categories, even though they are framed in quantitative and positivistic terms. Gray (ibid) continues to describe the increasing degree or precision if using *quantifiable* data collection techniques, such as *interval* or *ratio* methods. Again, in relation to the research questions and the objectives of the research, the use of interval and ratio techniques are not relevant to the non-parametric nature of the questions.

Having established the categorical (nominal and ordinal) nature of the questions, a presentation medium following the approach of *simple descriptive statistics* has been identified as most suitable. The absence of significant interval and ratio data, and the aforementioned filter level which presents the findings of the integrated team, negate the requirement for using a more complex software analysis package such as SPSS. Instead, the presentation mediums found in the basic MS Excel software package are considered perfectly adequate to present the data in context, and to allow for a sufficient degree of analysis and discussion. This deliberate aim of keeping the data presentation as simple as possible is reinforced from numerous credible and seminal sources. These include Robsons (2011) observations that complex methods of presentation and modeling are no substitute for thought and reasoning, and that simple displays and tables are often all that is required. This has powerful support in the findings of Rosnow and Rosenthal (1989), Cohen (1990), and Gorard (2006) who all champion and reinforce the method of presenting data in its most simplest form.

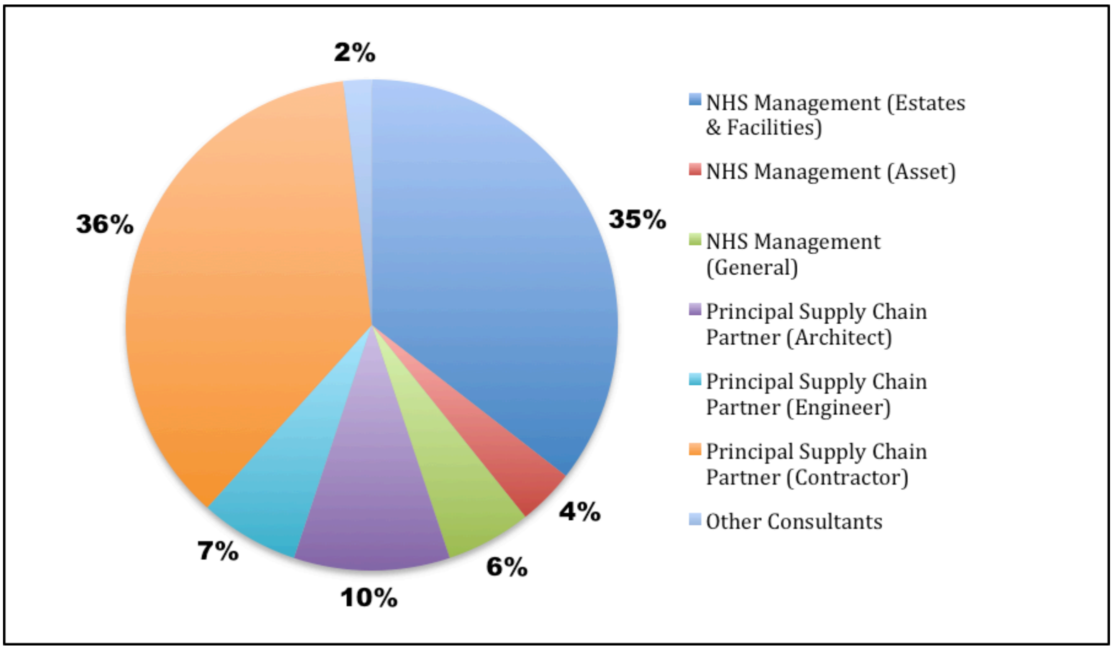


Figure 5.1. The Sample Frame

5.2.1 Characteristics of the Sample Frame

The selection of professional disciplines considered within the sample frame, is driven largely from the secondary data sources, and an understanding of the key participants and stakeholders in the asset/estate/facility management processes, and the subsequent involvement and connections with the standardized business case process which is mandatory in relation to the planning, design, and construction of capital projects financed by the public purse. Section 1 of the main questionnaire focused on the characteristics of the participants information following the same methodology employed throughout the literature review process. The spread of respondents identified in Figure 5.1 show a fairly balanced distribution of respondents from the 2 main sector disciplines which may be considered as NHS Management, and Design Team professionals. Given the limitation in size of the NHS Scotland estate specifically; the combined overall response of 105 is considered to be an excellent response rate.

As mentioned above; the structure of this section separated the core research dimensions of healthcare, refurbishment, and sustainability. It was shown that the highest level of experience was found to be within the larger hospital facilities such as the standard acute hospital and the specialist acute, respectively. The smaller the facility, the less experience the respondents recorded. This is a significant point, as it opens up the discussion on how the overall NHS Scotland healthcare estate is categorized. The *Annual State of NHS Scotland Assets and Facilities Report for 2012* (Scottish Government 2102) identifies that 92% of net book assets of NHS Scotlands £5 billion value, is property based, and that 64% of these property assets are in the acute sector. Contained within the same report, it is clearly stated that the shift from institutional to community based care is a key aim of the future service delivery model. This has potential implications for the efficacy of pursuing best value for money in design and operation, given that there is no distinction between the size of the project if it is required to participate in the standard business case process.

There is a discernible pattern which mirrors the sample frames experience in healthcare facilities, when the experience level was more precisely targeted in respect of the experience *specifically of refurbishment projects* in respect of the range of facilities. Again, the majority of experience is found in the 2 categories of acute hospital facility, with a weaker finding in the smaller community based projects. Again; this must be viewed as a significant finding in the context of the existing estate, and planned direction of community based service provision. The decision making process in these terms must be expanded from purely material specification and/or procurement decisions, to incorporate the strategic context of the care model itself. The sustainability model (viewed in its triple dimensional form of social, environmental, and economic factors) seems the natural model format through which to integrate and consider this seeming mix of tangible and non-tangible criteria. When questioned on their knowledge base of issues of sustainability (in the triple dimensional terms stated above), related specifically to the respondents own professional discipline, the overall self assessment of understanding was offered as 'Excellent' (15%), 'Good' (56%), and 'Average' (22%). Even discounting the 'Average' scoring, 71% of the respondents claim a good to excellent understanding of the issues of sustainability within their discipline. Given the trend for the sample frame which identifies a less familiar level of experience in regards to the community based facilities and care model, this raises the possibility of a knowledge and experiential 'disconnect' in understanding of the true capacity of the sustainability model and it's application to facilities outside of an acute hospital refurbishment setting.

In summary; the initial results and analysis of the participants information section demonstrate a relationship, or perhaps even the very foundation, for the framing of the main research questions.

5.3 Is there a requirement for a Decision Support Model for undertaking Sustainable Refurbishment of Hospital and Healthcare Buildings?

There are multiple factors which must be considered in addressing this question. A common theme was identified as a baseline for investigating the need for a decision support model, through asking the sample frame to rank the selected sustainability issues/criteria, in order of perceived importance. A key aim of posing this question was to observe how a very fundamental form of decision making was undertaken by the respondents (in the quantitative sense), and to consider the feedback on the exercise through the facility of commenting on the question itself, thus introducing a qualitative dimension to the data collection. The results (Appendix…) demonstrated that energy use and carbon emissions, closely followed by design quality, were deemed as the most important factors, whereas water use, and land use and ecology, were at the other end of the spectrum, as the least most important considerations. It should be appreciated though, that the scale difference between all 13 issues was not found to be dramatic in figurative terms, and this was reinforced from the qualitative data with a commonly aggregated response from the sample frame, that given the integrated nature of the criteria offered, to rank in an 'absolute order of priority' was not realistic and confusing. This discomfort from the respondents in ability to rank the issues, is observed also, in the context of the earlier question which asked the sample frame to self assess their knowledge base on sustainability in their discipline. As discussed in the previous section, the vast majority considered themselves to have a good to excellent understanding of the area. This strongly supports the findings within the literature review, notably by Braunschweig et al (2001) that the decision makers must have clear knowledge of the critical issues involved in the decision making process, although these are very often veiled at first. Lokens (2005) recognition that the fundamental objective of decision making to derive the 'optimal solution' is therefore challenged by the respondents difficulty and discomfort in attempting prioritise the 13 sustainability issues which are recognised as the standardized criteria through the NHS as an organisation.

It seems clear in this case, that in the context of the 13 sustainability issues alone, a realistic and practical approach must therefore have the capacity to evaluate the issues and criteria in a manner that will allow the decision makers to attach value judgments and measures of importance to the project in question. The question that was asked (to rank the sustainability issues) in itself, is not deemed to be of any great value in respect of the actual figures attached to the collected data, but this is in the context of considering the issues on a macro or generalized scale. Had the question been framed in the context of a single project which was known to the sample frame in terms of its form, functional, and oriented characteristics, it seems fair to suggest that the scales of importance may have appeared differently. The refurbishment process has been identified within the literature review as being inherently uncertain (Egbu & Lee., 2006) (Azlan-Shah., 2010) (Quah., 1988) (Aho et al., 1998) and when applied to the modern hospital as a built asset, these uncertainties are compounded by limitations in funding and the incorporation of backlog maintenance requirements within the refurbishment activity. The evidence at this stage, therefore seems to support the requirement, and the utility, of a decision support model of some form in application to the sustainable refurbishment of healthcare facilities. This does not however, imply that there are no current methodologies in use across the NHS in respect of the decision making process. Although from the entire sample frame, only 5% recorded experience using Multi-Criteria Decision Modelling techniques (which the responses relating to difficulties in ranking the issues seems to promote), the system of estate management, and the business case process could not feasibly function unless a decision-making system 'of some kind' exists. The stage is set in this case, for the development of the model prototype to introduce the multi-criterion aspect to the process, however, further research questions are identified in constructing a state of the art picture.

5.3.1 Do current tools and processes identify areas of priority in identifying key decision making criteria?

The current tools and processes used throughout both the estates management, and the business case process were identified within the literature review as being positioned within the guidance *and* documentation which pertain to both of these areas ('estates' in this context, must also be read as including asset and facilities management functions). The questionnaire was created to differentiate between the more 'standard' documentation in regards to the technical aspects relating to hospital construction and refurbishment projects, and the higher level asset and estates management documentation and guidance originating from NHS Scotland itself.

The 'standard' documents pertaining to the design and construction works associated with the refurbishment process were therefore presented to the sample frame. It was recognised that the document list is not exhaustive or completely inclusive of every document or guidance material, yet in the identification and consideration of criteria and subsequent alternatives/options, it is suggested that the decision making participants require a certain level of understanding (and access) to the legal and regulatory guidance documents. In all documents stated, the majority in most cases, claim a good understanding. Figure 5.2 illustrates the results. The majority of the respondents claim a moderate to good familiarity level with the documents included, with a fairly high comparative figure of respondents who claim a detailed understanding. Given the context of the documentation, such a positive response in regards to familiarity must, by a process of association, imply that areas of priority may be inferred through experience and knowledge of the sample frame and thus, have a causal effect on identifying the decision making criteria. It is difficult to argue, that in the context of the results, there is an inherent sapiential, or heuristic knowledge platform that allows for priority setting in a consensus-based context. A review of the documentation however, identifies no specific mechanism for prioritizing criteria in any measured or calculated manner.

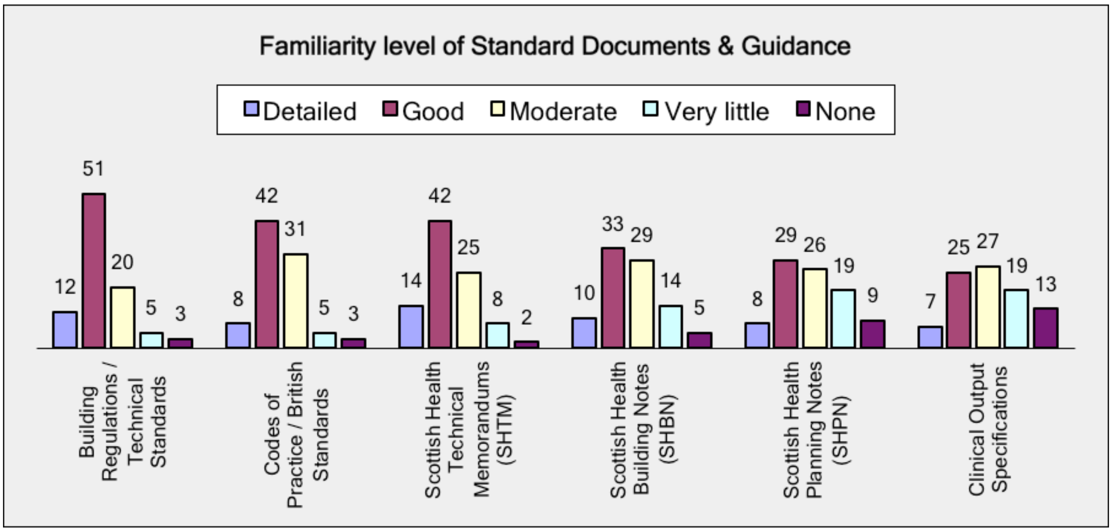


Figure 5.2. Familiarity with standard documents

This 'inherent' knowledge which is implied from the familiarity with the documents and guidance, is therefore, more surprising when contrasted with the results of a further question (Figure 4.3) asking if the sample frame were familiar with the *Property Appraisal Guidance Document for NHS Scotland* (Health Facilities Scotland 2011) The first point of interest to note, is regarding the role and the content of the document itself. The aim of the document is to provide the necessary guidance for each Health Board to feed into the requirements of their Property and Asset Management Strategies (as discussed within the literature review) Significantly, the guidance follows a risk based methodology, measured within the compilation of a property schedule. A condition or performance ranking, is applied to each of the 6 identified facets:

1. Physical condition
2. Statutory compliance
3. Environmental management
4. Space utilisation
5. Functional suitability
6. Quality

The backlog maintenance costs are derived from the appraisal process, and the specific issue is then ranked and scored with a basic consequence versus likelihood matrix. This 'role summary' is justified within this section, as the content of the document (as may be perceived from the above summary) presents a process of identifying key decision making criteria and ranking them in order of priority. In essence, identifying a range of goals and/or objectives. The results therefore indicate, that there is a disconnection between the guidance and documentation in technical terms, and the familiarity with the guidance and methodologies in management (asset/estate/facilities) terms. This suggests a weakness in integration of the high level aspirations and ambitions from board or authority level, to the project specific technical challenges and solution requirements at design team and physical works planning level.

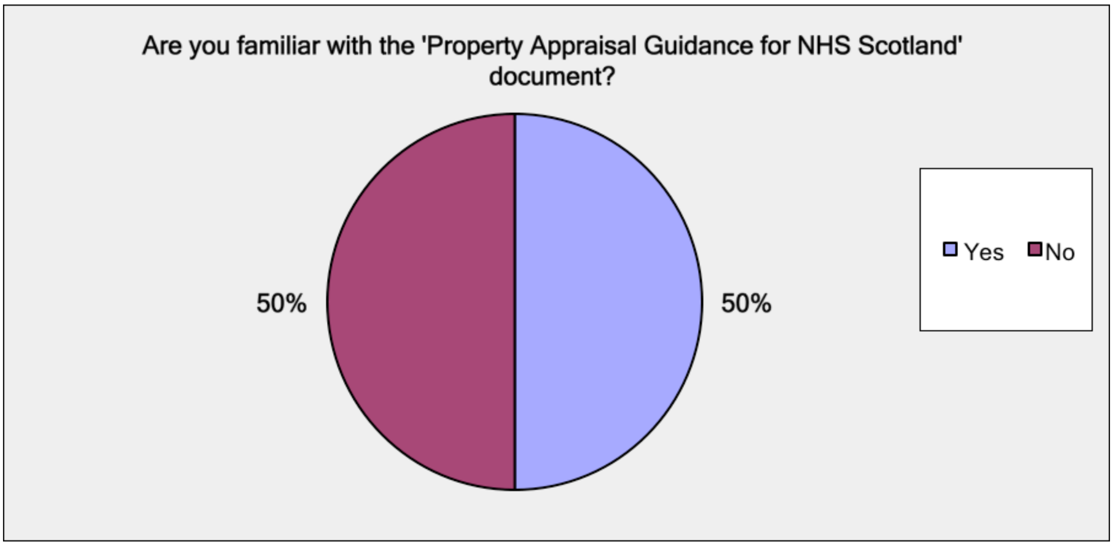


Figure 5.3. Familiarity with Property Appraisal Guidance document

The second point of interest in the results displayed in Figure 5.3, was the exact 50/50 separation between those respondents familiar with the guidance, and those not. In broad terms, the sample frame is divided into 2 main management disciplines, namely the NHS professionals, and the Design Team professionals. As the *Property Appraisal Guidance Document for NHS Scotland* document is very much a bridging document (in the sense that although it is an NHS document, it is concerned primarily in this context, with the built environment and works required within it), the possible implication which needed analysed in greater detail, was to understand if this 50/50 characteristic followed a pattern of professional discipline. It was essential in this case, to filter the responses to a more detailed layer. Figure 5.4 presents the results of this additional filtering layer. What is immediately obvious from the data presented within Figure 5.4, is that the NHS Management disciplines are overall more familiar with this document. As noted above, this is not unusual, given that it is an NHS document. The NHS Management – Estates & Facilities stream, does however record that a quarter of the respondents are not familiar with the document. This is actually a very significant finding when the NHS Managers collective response is divided by percentile. The Estates & Facilities responses account for 80% of the total NHS responses. 25% of these profess no knowledge of the *Property Appraisal Guidance Document for NHS Scotland* document. Given that this is the foundation document for constructing the property appraisals for the individual Health Boards, this is surprising and potentially highlights an weak link in understanding the condition of the portfolio, which may have the fairly obvious knock on effect that the decision making process in conjunction with the PSCP may be negatively affected. The data collection was not designed to identify which health board or organisation the respondents were from, however it is noted that such an exercise might provide evidence of regional trends. This will be noted for the conclusions and recommendations section.

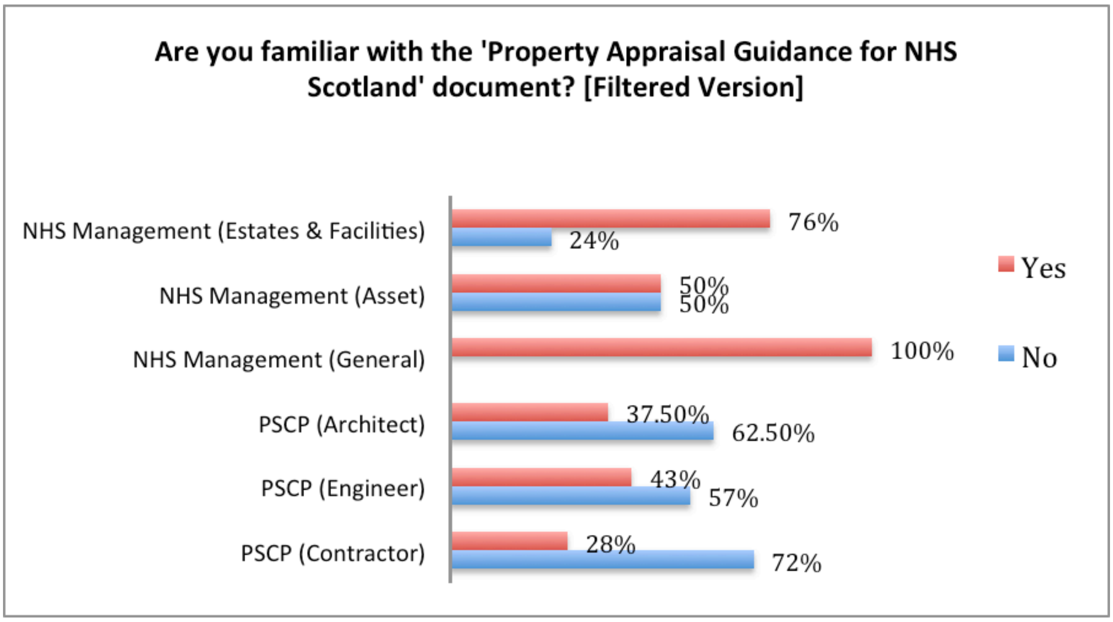


Figure 5.4. Familiarity with Property Appraisal Guidance document – Filtered version

Analysis of the PSCP responses to this question (in the additionally filtered version) show an almost exact opposite of the NHS Management findings. The majority of the responses were from the PSCP – Contractor stream, accounting for over 60% of the total PSCP responses. 72% of this 60% profess no knowledge of the document. Given the nature of the procurement routes being undertaken, as identified within the literature review, it is the Contractor who is identified as the key PSCP participant in terms of numbers and range of responsibilities.

On the basis that the *Property Appraisal Guidance Document for NHS Scotland* document has been identified as a key bridging document, and reinforced by the fact that the only identifiable mechanism for framing and visualizing the requirements of the built estate in terms of prioritization, there is no evidence from the secondary or primary data to suggest that a criteria identification process exists in any standardized format. The heuristic approach to identifying and agreeing criteria for the *specific project* is shown to have a potential weakness in that key participants of the projects decision making process may be unfamiliar with the mandatory high level guidance.

5.3.2 Do current tools and processes offer a best option, or best alternative, for the project, based on a project by project basis?

The significance and relationship to the research question stems from the hypothesis that for the decision makers to *understand* and *identify* what the best option or alternative may be in regards to a given goal or objective (and it is reiterated that this comprises the first 3 steps of the 5 step MCDM process as identified by Zarghami & Szidarovsky 2001), then they must also understand the limitations and parameters of the guidance and technical documents. The eligible options (stemming from realistic criteria) must therefore be compliant and appreciative of, the technical and managerial allowances framed in the standard documentation. Reference must be made at this point, to the relationship with the previously discussed knowledge levels and familiarity of the sample frame with the standard technical documentation and guidance. Regardless of the current tools and processes available, a poor knowledge base in the fundamentals of construction technology, and the planning and construction process related to healthcare facilities, would imply a foundation weakness in option and/or alternative selection. Face to face interviews with contractors, NHS estates managers, and Health Facilities Scotland asset managers, resulted in a common experience within the standard business case process on new build and refurbishment projects, that options appraisal and selection is often based on experience from within the decision making team, that methods, systems, and technologies are selected based on the fact that they have been used successfully on a previous project. Although on the face of it, this may be perceived as a logical methodology, by its nature, it does not consider the project as a stand alone facility. The literature review identified one of the key challenges and limiting factors of a refurbishment project specifically, as being the integration of the new works, within the existing (and often unalterable) orientation, form, and function, of the facility.

Refocusing more directly onto the research question, it was deemed essential to firstly gauge the level of familiarity with the main tools and systems prior to analysis and calibration against the secondary data findings of the literature review. Figure 5.5 demonstrates the respondents results in regard to the selected systems. BREEAM is identified as the most well understood of all the systems, closely followed by HAI-SCRIBE, ADB, and then AEDET. BREEAM and HAI-SCRIBE are, by their mandatory and project approval nature, unsurprisingly the two leaders. As with the importance assigned to heuristic knowledge of the technical guidance and documentation, the identified HAI-SCRIBE team members, must possess a minimum level of experience and capability, and clear performance criteria is found within the implementation strategy document (National Services Scotland 2007 pp.6) The methodology however, mirrors (to an extent) that of the Property Appraisal Guidance, in that it seeks to identify and assess the risk factors (and ultimately to manage them). In terms of identifying options, it is proposed that there is a clear link, through the process of criteria identification, of which HAI-SCRIBE must feature prominently. Again, in alignment with the property appraisal methodology, the process is identified as highlighting and even ranking the issue, but without any formalised mechanism for consideration and solving.

Similarly with BREEAM. The results show a very positive response in respect of knowledge base across the disciplines, and given the nature of the credits and issues found within the assessment, coupled with the knowledge of the built asset and the refurbishment/construction process in which to give the issues context, a majority response of moderate to detailed lays an excellent foundation.

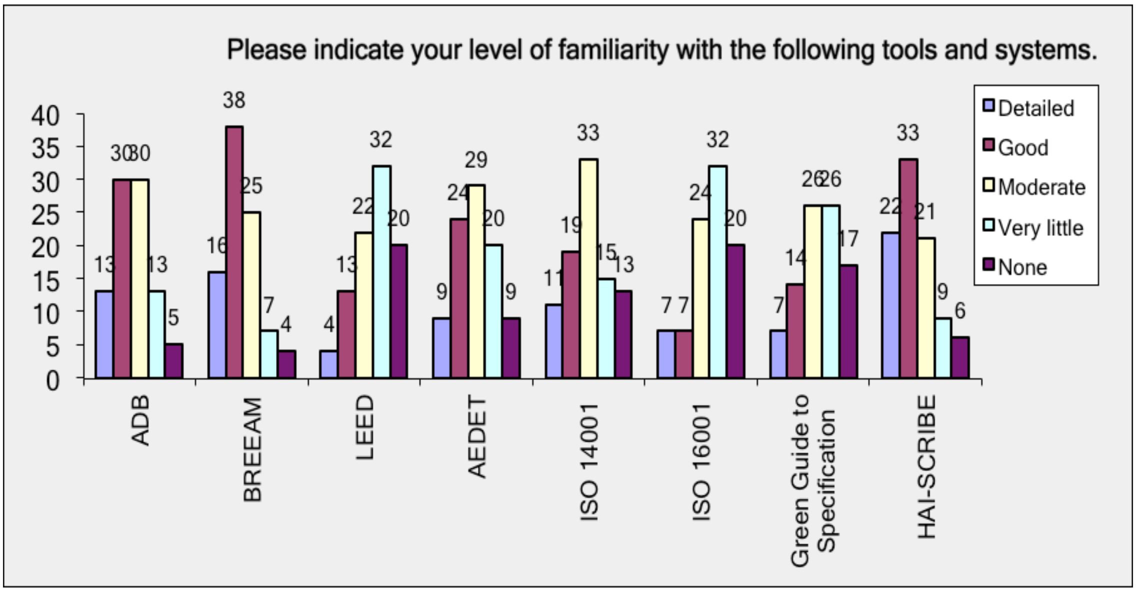


Figure 5.5. Familiarity with tools and systems

The structure and weighting of the credits within the assessment however, are clearly discernible in being highly prescriptive in performance requirement. Even where a system, element, component, or technology is clearly and unambiguously required to achieve a credit score, there is no mechanism or guidance within the assessment itself on selecting the 'best fit' or best 'value for money' option. The implication of this being that BREEAM has no built in driver to achieve best value for money for the project. Pursuing Value for Money is the duty of the business case participants when going through the standard SCIM process. This then, seems to demonstrate a weakness in integration or targeting between the mandatory business case requirements as undertaken throughout the SCIM process, and the correspondingly mandatory BREEAM assessment. Given it's significance and prevalence within the healthcare construction and refurbishment of both SCIM and BREEAM, the research question must be continued in regards to considering the decision making process (and selection of 'best fit' options). The characteristics of the refurbishment process also have weight in framing the question, in assessing the performance or validity of current systems on a project by project basis.

5.3.3 Is there a formalised management/facilitation process, that ensures that a rigorous and demonstrable decision making process has been undertaken? (within the mandatory institutional requirement to demonstrate Value for Money)

The *Property Appraisal Guidance Document for NHS Scotland* document, and the most commonly used standard guidance and technical documents, have been considered in respect of their capability to identify and select criterion and options in regard to individual projects. These however, are themselves component parts of the broader decision making process. A key objective of the research is to identify the decision making process as they currently exist. The literature review explored the composition and the purpose of the *Scottish Capital Investment Manual* (The Scottish Government - a 2010) and it is clear that the decision making process at project specific level is incorporated within the Business Case guidance. The Initial Agreement phase of the process specifically identifies this, in stating that the Initial Agreement…

"…provide(s) a basis for better decision making through reaching agreement from the outset about key issues from the options" (ibid pp. 27)

The guidance is also clear however, on what it considers to be…

"…probably the most important stage of all…" (ibid pp.31)

which is the identification of the 'Investment Objectives'. This section is not intended to repeat the findings of the literature review, and yet summary information on the functional intentions of the SCIM are essential in providing context within the research question. This is no more relevant, than in re-emphasising the fundamental aim or duty of the SCIM and associated business case process, which is to…

"…clearly demonstrate and deliver value for money for the taxpayer" (ibid pp. 4)

It follows naturally from the above contextual positioning, that a an essential question to be asked of the sample frame, was there level of understanding of the SCIM. As an integrated sample population, the results presented no immediately identifiable findings that could be deemed 'significant'. Figure 5.6 shows a fairly even spread of responses, with roughly two thirds of the sample population in the reasonable to excellent categories.

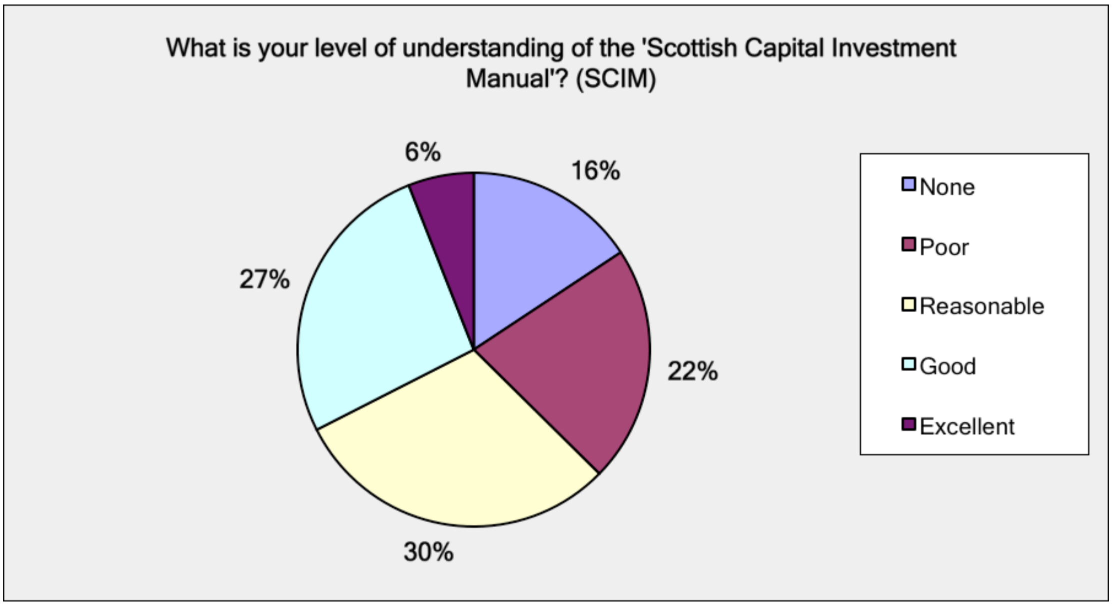


Figure 5.6. Understanding of SCIM

Similarly to the results analysed previously in regards to the property appraisal and guidance document, it is the relatively 'unremarkable' aspect of the results which necessitated the requirement to filter the results by discipline. In terms of decision making, and the very stewardship of the project planning, design, and ultimately delivery, the SCIM must be considered as the core document binding both discipline groups together in regards to progress and ultimately (as stated previously) in ensuring that best value for money has been achieved. Again; mirroring the responses regarding the property appraisal guidance document, the two dominant response groups by far, are the NHS Management – Estates & Facilities, and the PSCP – Contractor discipline streams. What is significant, is the knowledge level recorded within these two dominant disciplines. The NHS Estates & Facilities managers demonstrate that 81% of the respondents possess a reasonable to good understanding of the SCIM. Alternately; the PSCP – Contractors demonstrated a combined 24% rating in the same categories of reasonable to good (20% being in the reasonable category). What is also highly interesting in the PSCP- Contractor response, is the 76% response in the poor to none categories. On the basis that the SCIM is the only identifiable guidance document that discusses the decision making process in terms of criteria, options, and value for money; it is fair to infer that such a negative response rate in terms of knowledge and understanding, places the business case process, and the decision making process within it, on a fairly fragile foundation. Figure 5.7 illustrates the disparity discussed. These findings must also be considered within the previously discussed characteristics of the sample frame. 67% of the integrated population sample are recorded as possessing in excess of 10 years experience, and a further 24% with between 5 and 10 years experience. The level of experience in regards to hospital and healthcare facility types, *and* in regards to the experience of refurbishment as an activity within the differing facility types, was found to be of a good to high level. The seemingly contradictory responses which identify this high level of experience, with a relatively poor level of familiarity and understanding of the SCIM process, support the earlier analysis that the status quo of criteria and option selection, is based on heuristic principles of simply repeating that which has worked before.

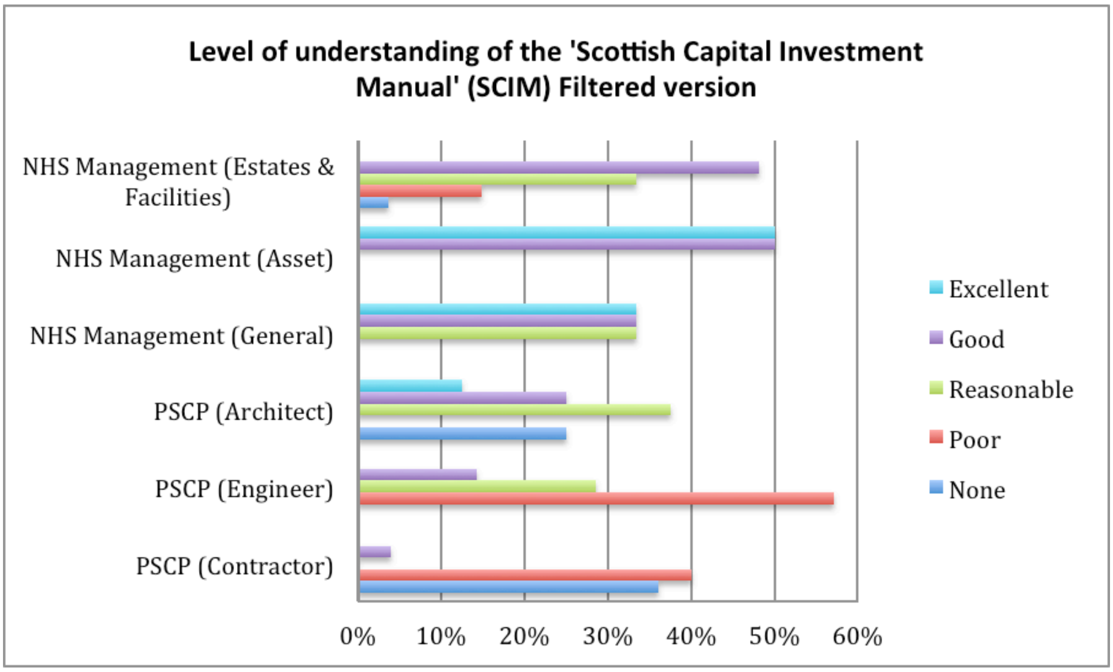


Figure 5.7. Understanding of SCIM – Filtered version

The focus must be brought back at this point, to consideration and analysis of the concept of 'Value for Money' within the business case process. It has been discussed already, that a core imperative of the business case process and the SCIM guidance is to achieve best Value for Money for the project. To assess whether there exists a formalised decision making process that pursues this aim however, it was deemed logical to focus on the term itself and to explore the range of definitions as perceived by the integrated sample frame. In essence; if the prime factor of the guiding exercise and process is

Value for Money…it is essential to understand if there is a commonly agreed perception of what value for money actually is.

A quantitative approach was discounted in assessing the sample frames understanding of value for money as a definition. By it's nature, the professions and experience of the respondents is more akin to a value judgement, and therefore a qualitative approach was deemed essential. The sample were asked to specifically focus on the area of healthcare refurbishment, and to provide a statement on what they considered the definition of 'value for money' to be in this context. Robson (2011 pp. 465-466) captures the benefits of a narrative approach from the sample frame in identifying responses which are potentially 'rich, full, and real'. From the entire sample frame, a 55% response rate was returned, which is deemed credible enough to apply analytical coding and thematic techniques. Given that the responses themselves were primarily in the form of sentences and short paragraphs, consideration was given to simply presenting the responses in their raw format (a methodology identified as valid in some research projects by Strauss and Corbin 1998). The 'raw format' responses are appended in the appendices. However; Gray (2004) presents the alternative validation that proposes an objective synthesis and description of the selected data. Given the research questions objective in ascertaining the presence, or non-presence, of a linear management function, and given also the professional characteristics of the sample frame, Grays (ibid) more structured approach has been identified as offering best value to the interpretation of the responses, despite the concise nature of the responses. Despite the stated concise nature of the responses, and the relatively small percentile, Gray (ibid pp. 323-324) identifies that qualitative research works well with small samples of people, especially (as in the context of the research question) when designed to be *purposive* as opposed to random in nature. A simple method of *content analysis* therefore, has been used to code, theme, analyse, and interpret the data responses.

In general, the findings as displayed in Figure 5.8, show alignment with the concept of value for money throughout the literature. 12 key themes were identified within 4 over-arching coding groups. It must be highlighted that, as with the core challenge of prioritizing an inextricably integrated issue such as sustainability, there were also unavoidable overlaps and merging of themes from the sample frames response. The themes identified in Figure 5.8 must, in the context of the research question, be considered as foundation principles in recognizing the key criteria which are necessary for undertaking the decision making process within the SCIM guidance. The challenge and the limitation of these findings, are the 'stand alone' nature of their presentation. No baseline exists with which to benchmark the thematic frequencies, which weakens the ability of the analysis to identify any credible or valid patterns or themes. To this end; it is noted that further research and data collection would be beneficial, especially in the context of a project specific case study. The themes identified in this section are essentially generic, and a variance analysis might be useful if the sample frames minds were focused on a tangible reality as opposed to generalized statement.

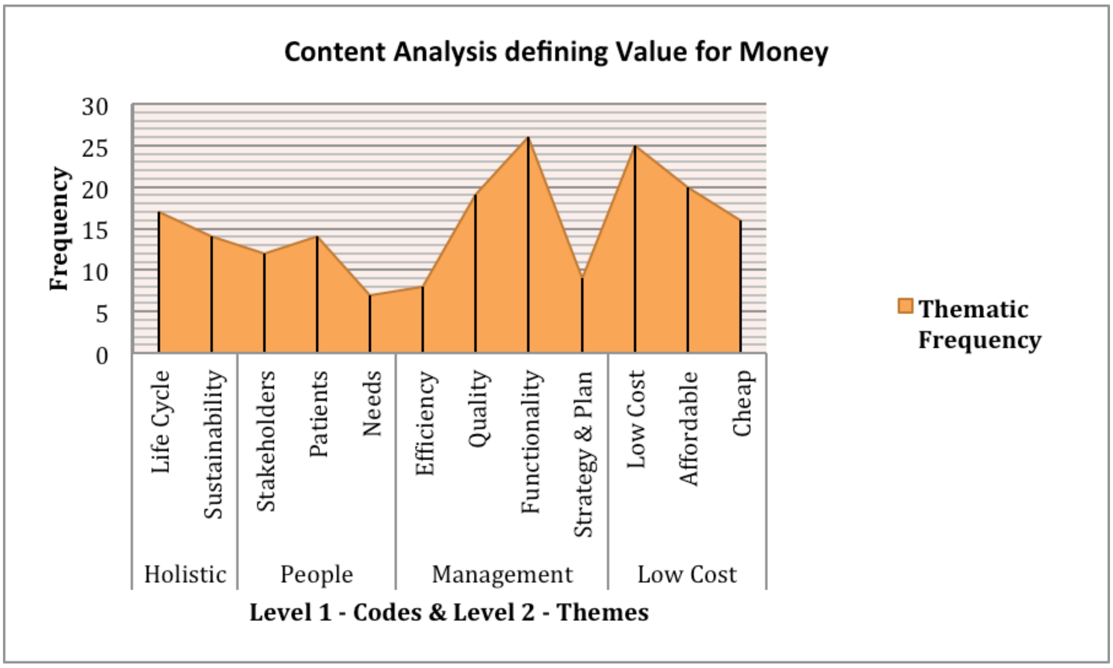


Figure 5.8. Qualitative analysis of sample frame defining Value for Money

The findings and analysis are still considered of value to the research exercise, and perhaps the most significant indicator of what the sample frame considered the most important Value for Money *criteria*, can be identified as functionality, low cost, and affordability. This is closely followed by quality and the pursuit of 'cheap'.

Perhaps a more significant finding, is the comparatively high frequency of all themes within the 'low cost' coding category. This is matched only by both quality and functionality. When considered against the widely recognised 'quality triangle' dimensions of time, quality, and cost; the findings support the dimensions of quality and cost very clearly. It is worth noting, that although time is represented in the 'holistic' coding range by means of life-cycle considerations (itself a significantly scoring theme), the context of what 'time' implies within the research question (and the survey question) must be understood in terms of longevity of the structure and the economic considerations therein, as opposed to the duration of the physical refurbishment project itself. This is an important distinction, especially in elation to the wider sustainability model and it's relationship to Value for Money as a concept.

Investigating the sample frames understanding and definition of Value for Money therefore, has great bearing on how the facets and potential criteria of the decision making process are framed by the decision makers. There is a limitation to these findings, in the sense that the integrated NHS and PSCP teams have responded. A further exercise would be of value to measure and assess the views and perceptions of VFM on a discipline by discipline basis. Regardless of the level of filtering or detail discussed within this section of the results, the platform is set in anticipation of the next main and sub-research questions focusing specifically on the application of MCDM techniques. The MCDM techniques are themselves validated by the phenomenon of the inability to *truly* rank and prioritise the decision making criteria.

5.4 Are Multi Criteria Decision Making techniques applicable to the undertaking of sustainable refurbishment of hospitals and healthcare facilities?

It was discussed in the previous main section (5.3) that the actual experience level of the sample frame in the use of MCDM techniques was limited, with only 5% confirming that they had positively used some form of modeling (Figure 5.9). This however, is framed within the context of the asset management and property appraisal guidance, and also the standard format of the capital investment business case process. The research questions discussed previously, in sections 5.3.1, 5.3.2, and 5.3.3, respectively, identify in the results, that despite bias in professional disciplines, there is generally a good understanding and experience level with the guidance and process referred to above. As evidenced and discussed in detail, throughout the literature review and the contextual background chapters, the current guidance and processes are inherently constructed from a vast range of differing and often competing criteria. Reference is again made, to the discomfort and inability of the sample frame, to prioritise (with any degree of consensus), the 13 sustainability issues. The sheer breadth of issues to be considered in understanding, and deciding upon, the integrated factors discussed throughout the literature review and contextual background, provide the inference, that regardless of the research question being asked, the sample frame, have participated in and been required to work within, a decision-making space that by its very nature is already MCDM in nature. Although the response of 5% discussed earlier is very small in the overall context, it is reiterated that this question sought to assess experience with specific modeling techniques. This then, suggests that even though the sample frame were not aware that they were undertaking a form of MCDM, the very nature and structure of the management and decision making processes has been an unavoidable constant demanding that conflicting criteria and options selection are compared and prioritised as a matter of course. This could be expanded further yet, to suggest that if the sample frame (in its entirety) had not (consciously or unconsciously) used MCDM techniques, then the business case would not have been able to progress. In addressing the specifics of the research question, this would indicate that Multi Criteria Decision Making techniques are indeed applicable to the undertaking of hospital refurbishment projects, by virtue of the fact that they already take place. This takes the question forward into exploring the potential benefits (or otherwise) of formalizing this inherent process, within a standardised and systemic framework. To do this, the sub-questions that follow, must seek to understand and align the MCDM process in the context of the sample frames experience, the viability of integration with the existing (and often mandatory) systems, and an assessment of the benefits of MCDM in satisfying the core requirements of the legislative and institutional requirements.

5.4.1 What is the level of knowledge and application of MCDM techniques in regards to the current Business Case process?

There are similarities to be understood in considering this question, with the research question '5.3.2' which discusses the presence (or not) of best option or alternatives functions within the main tools and systems encountered within the field (See figure 5.5) Although the discussed tools and systems do not in themselves possess any notable MCDM function, the decision making process is carried out in respect of the guidance and the specification requirements laid out in the selected documents. This, as discussed, is significantly affected by the knowledge base of the decision makers. The discussion however, must be steered back to the specific inquiry into MCDM processes. The literature review has discussed this field in depth, and it is understood that although there exists a heuristic level of MDCM capability in myriad actions and activities throughout the planning, design, and construction processes; utilisation of MCDM as a science or discipline, is very different. The first step in this case, was to explore the sample frames experience of using MCDM techniques to provide a knowledge or experiential baseline. The sample were queried firstly on whether they had ever participated in, or facilitated a process that involved MCDM techniques. A follow up question to those who responded that they 'had' done so, requested that to the best of their recollection, the type of MCDM process was supplied, together with the purpose for its use.

The overwhelming majority of respondents (87%) recorded no experience at all in MCDM techniques. As discussed within the literature review, the main guidance on the Capital Investment Processes, have very little in the way of guidance or direction for decision making with multiple factors and variables involved, which may be competing. Compare this fact to the HM Treasury's (2011) own definition of what the appraisal process (which in these terms refers to the Business Case process) should be…

"The process of defining objectives, examining options, and weighing up the costs and benefits, risks and uncertainties of these options before a decision is made"

It might be easily argued, that as evidenced by the inclusion of the multiple criteria considerations even within this definition, an MCDM approach is not only desirable, but 'essential'.

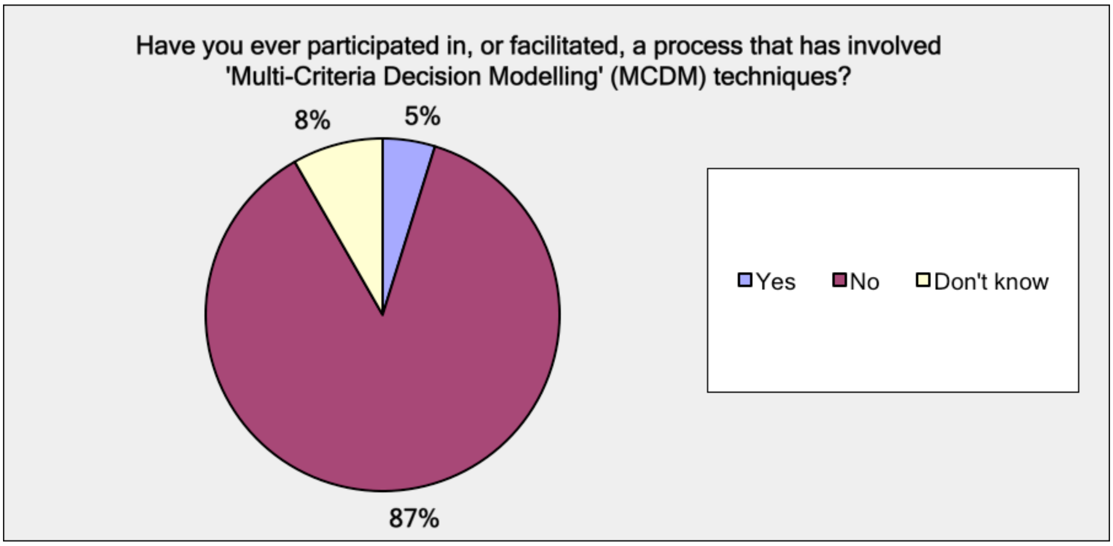


Figure 5.9. Experience of using MCDM techniques

So: the inference from the sample frame (Figure 5.9) implies that there is a very poor understanding or experience using processes which are deemed essential within the capital investment guidance. This then begs the question…*what is the sample frames knowledge of the capital investment process?*

As the respondents were specifically targeted form their connection with projects relating to NHSScotland, this was framed in the context of knowledge level within the *Scottish Capital Investment Manual* or 'SCIM' (2010). There was a fairly evenly distributed response to this, in regards to level of understanding, as discussed previously, and shown in (Figure 5.6) Closer scrutiny of the SCIM, identifies the prevalence of decision making and identification of criteria and options peppered throughout, and more so, as key connection and integration points for the successful progress of the Business case process. There are literally, too many examples to reference, without in effect, rewriting large sections of the SCIM. Taking a 'key example', page 57 (ibid) states a key aim of the Outline Business Case (OBC) is to…

"Identify the option which optimises Value for Money and overall sustainability"

What is also demonstrated here, is the connection between the sample frames professed knowledge of both 'sustainability' and also their views on what constitutes 'Value for Money'. These were looked at in more detail in the previous sections, and on the whole, were found to be fairly well understood, or defined (respectively) by the respondents. This being the case, and with the requirements for a multi-variable approach to identifying and selecting best options for the project, the very low knowledge base of MCDM techniques is a significant gap or disconnection between the sample frames 'usual' approach; and that which the literature review, and the requirements of the guidance itself, deem necessary for the optimum chance of success. What is demonstrated here. Therefore, is that the primary data supports the hypothesis that there is a very poor level of knowledge or application of MCDM techniques in the current business case process, despite the obvious benefits and/or requirements for using them.

This finding raises another question for the researcher. It may be instructive to explore 'why' such a gap or disconnection exists. Is this a case of simple lack of exposure and/or understanding of MCDM tools and techniques in general, or are the most recognised forms of MCDM viewed as being too mathematically complex and labour intensive across the disciplines? Perhaps a clue to this may be in the previously discussed 'follow up question' to the query on MCDM knowledge levels. The minority who recorded that they had used 'a' form of MCDM technique, were asked to recall the type and the purpose. The responses were not significant in the identification objective, however the reasons for use were more commonly recalled. Even so, there was a thread of uncertainty throughout the responses which are listed below:

1. Our own
2. Not sure

3. Distributive
4. WSM (Weighted Sum Model)
5. Prioritisation of Capital Investment Plan
6. Options for Highland Theological College (UHI) strategy
7. Masterplanning process
8. To prioritise potential projects to be carried out in the capital plan

The results are interesting in their descriptions, especially response 3 and 4, which actually name the decision making model used. However, given that the affirmative response from the sample was so low (Figure 5.9), and that this minority sample is further filtered by such a difference in MCDM types and uses, these results are not deemed to be of great value in identifying trends in MCDM use. What is recognised however, is that it is proposed that the low response rate in this category, and the discussed fragmentation of individual uses, then there is still potentially a significant finding here. The existence of what may even be referred to as a form of null hypothesis, reinforces the main question finding that there are no MCDM applications and processes applied to the business case process. The little that has been identified, displays a lack of standardization which reinforces also, the previous findings in section 5.3.3 that the most formalised processes currently undertaken, are done so on the basis of individual and project by project experience.

5.4.2 Are MCDM techniques compatible with the existing systems and processes used within the current Business Case process?

There is a caveat to be highlighted at the outset of this section, in that it important for the research to clarify what is understood in this context by the term ‘compatible’. In the first instance, compatibility refers to the potential for participation by the user, within the framework of the guidance (SCIM) and the asset appraisal based actions undertaken within the NHS own capital assets guidance documents (such as the Property Appraisal Guidance document, or the Property Appraisal Management document). In other words…given the techniques that are offered and used within these guidance documents, is there a ‘good fit’ (or for that matter, a worthwhile one) for employing and integrating an MCDM approach? The second interpretation of compatibility is that of the actual Modelling interfaces themselves. So; if it is accepted that MCDM techniques are attractive, and a methodology (or model) has been identified which is powerful enough to address the decision making objectives of the business case process, then what are the compatibility challenges or possibilities in regard to the software platform itself. Meetings and discussion with the *Asset Management Team* of *Health Facilities Scotland* recorded the agreement from the group present, that it was not in the interests of the NHS or the PSCP involved with capital projects, to be presented with "yet another model or tool". This is a very telling observation, and branches into validity of the research aims and objectives overall. The development of the model is presented in a stand alone chapter which will explore and discuss the software and practical interface issues. For the purposes of the wider research question, as described here, the interpretation of 'compatibility' is referred to the first example looking at the interface points with the user and the current guidance documents and suggested methodologies used for the decision making process.

To measure compatibility in this context, it is necessary to frame the responses from the sample frame in the context of the literature review. It was a deliberate design feature of the questionnaire, that the entire process, beginning with high level policy, and culminating in the undertaking of the refurbishment activity, were presented as questions in a deconstructed way. What this means is that each document or process was evaluated in it's own right. The myriad and complex stages of the system (which are not necessarily repetitive on different projects) were viewed as making an inquiry into awareness/knowledge/understanding etc., of the entire process, as not very meaningful in respect of the data that would be returned. To this end, and as discussed above, the literature review identifies the proposed key integration points for the decision making process to be undertaken in the Property appraisal Guidance process, and the SCIM process respectively. It follows then, that the level of knowledge in regards to the processes overall, will give an indication of the sample frames ability to gauge whether MCDM methods are compatible. Essentially; what is the baseline?

At each end of the spectrum, Figures 5.3 (Property Appraisal Guidance) and 5.6 (Scottish Capital Investment Manual) have been discussed earlier. Figure 5.9, which explores the experience base with MCDM techniques is also relevant here. The 'disconnect' in knowledge between the NHS professionals and those associated with the PSCPs is again brought into focus. A key interim phase in the continuum described above, is the information collected and recorded by the NHS Asset Managers/Health Boards in their Property and Asset Management Strategy (PAMS) documents. Key characteristics of the documents are the PAMS are the key mandatory questions that provide the framework, of:

1. Where are we now?
2. Where do we want to be?
3. How do we get there?

It is reiterated that this is revisiting the findings of the literature review, however the context is important for the research question. As the 'facility specific' issues of backlog maintenance and other property issues are contained within the PAMS, the sample were firstly questioned on their knowledge of the document (Figure 5.10)

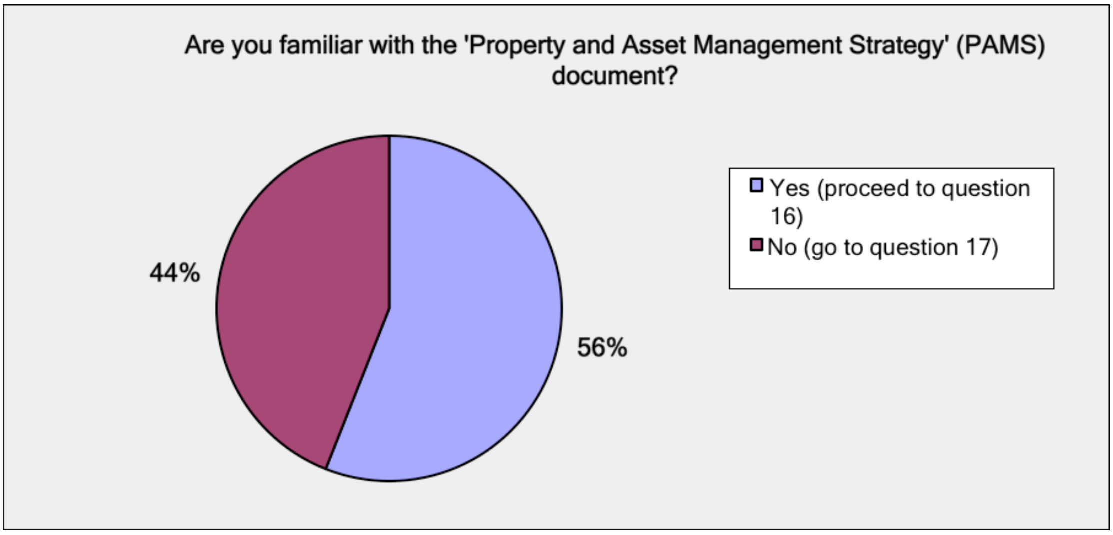


Figure 5.10. Familiarity with PAMS

Figure 5.10 shows a 56% familiarity (or just over half) from the sample frame. This opens up subsequent query of what the general 'make up' of each group is. As described in the section addressing the Property Appraisal Guidance (Figure 5.3) the fact that the sample frame is split into two main professional groupings (NHS and PSCP) highlights an interest for the research to explore if there is a correlation between the general discipline, and the knowledge level. To this end, a further sub filter of the results recorded the knowledge levels by discipline (Figure 5.11)

Given that the PAMS document is an NHS document, the results are perhaps unsurprising in that they demonstrate an overwhelming positive on the side of the NHS practitioners.

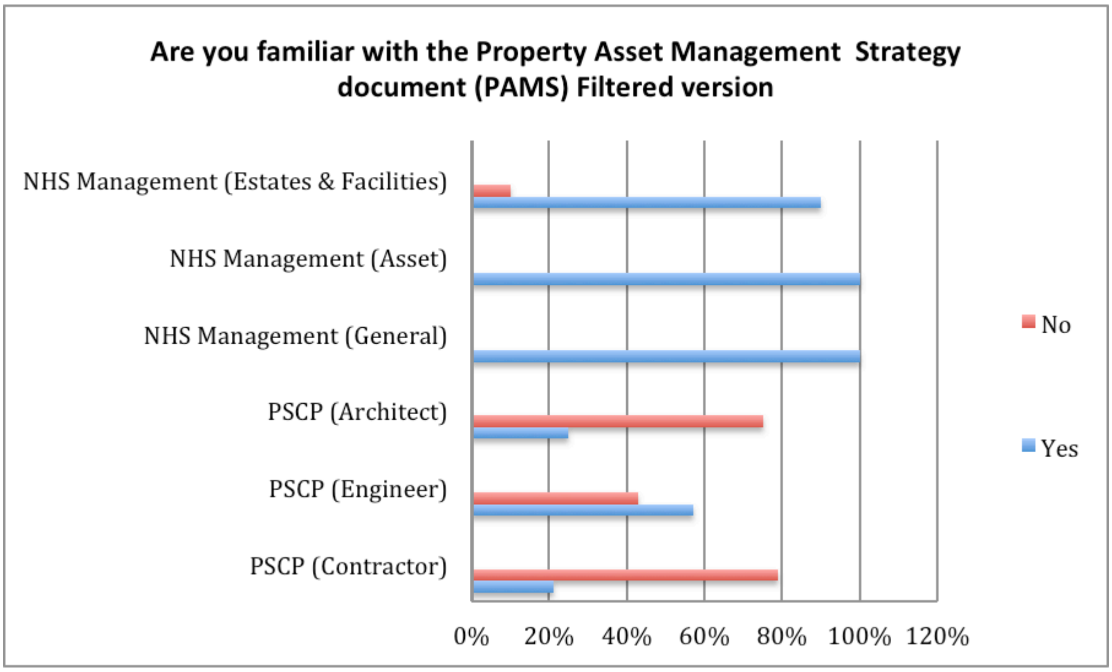


Figure 5.11. Familiarity with PAMS (Filtered version)

But again; as interesting as these findings are in themselves, what is the relationship or the correlation between these and the potential compatibility of MCDM techniques within the current processes?

The key to understanding this, and to extrapolate meaningful data supporting the discussion, are once more framed within the secondary data findings of the literature review. The process (or as referred to earlier…continuum) is once again integral to placing the integration potential. In essence; what the literature review and the guidance recognises, is that the process of identification, costing, and prioritizing of backlog maintenance (and associated built asset) issues, is carried out at the 'front end' by means of the NHS property appraisal processes. This is information which is stored and the EstateManager Tool (3iStudio. Trademark) is the suggested repository for this information. It logically follows, that once the areas of concern are identified, then a *transition phase* must occur, which generates the requirement for a physical refurbishment project to be planned. This transition takes the areas identified into the early phases of the SCIM process, as this is where the PSCP who will design, procure, and carry out the physical works will become involved. It is proposed that it is fairly self evident that when the PSCP enter the process (by means of the SCIM), then they will be basing their decision making processes, wholly or in part, on the data and performance rankings which are contained within the PAMS. Figure 5.11 indicates that the knowledge levels of the PAMS document are noticeably low in regards to the majority of the PSCPs. This in itself points to a significant finding, in the sense that if there is such a lack of awareness of the foundation documentation of the processes front end, how can the project demonstrate a rigorous, credible, and Value for Money, decision making process?

MCDM techniques (and the methodology employed by the prototype) have facility to ensure that there is a structure to this process. The identification of goal, criteria, and options provides a backward looking (or continuum spanning) inclusion of the entire process. In continuation of the findings represented in Figure 5.11, it was then necessary, to filter this issue in greater depth. The sample were asked to provide greater detail regarding the interface between the PAMS/SCIM (or NHS/PSCP) by stating if in their experience, or opinion, the findings within the complete PAMS documents (or the Property Asset Register) were ever discussed in the initial appraisal or outline design phase of a potential refurbishment project (Figure 5.12)

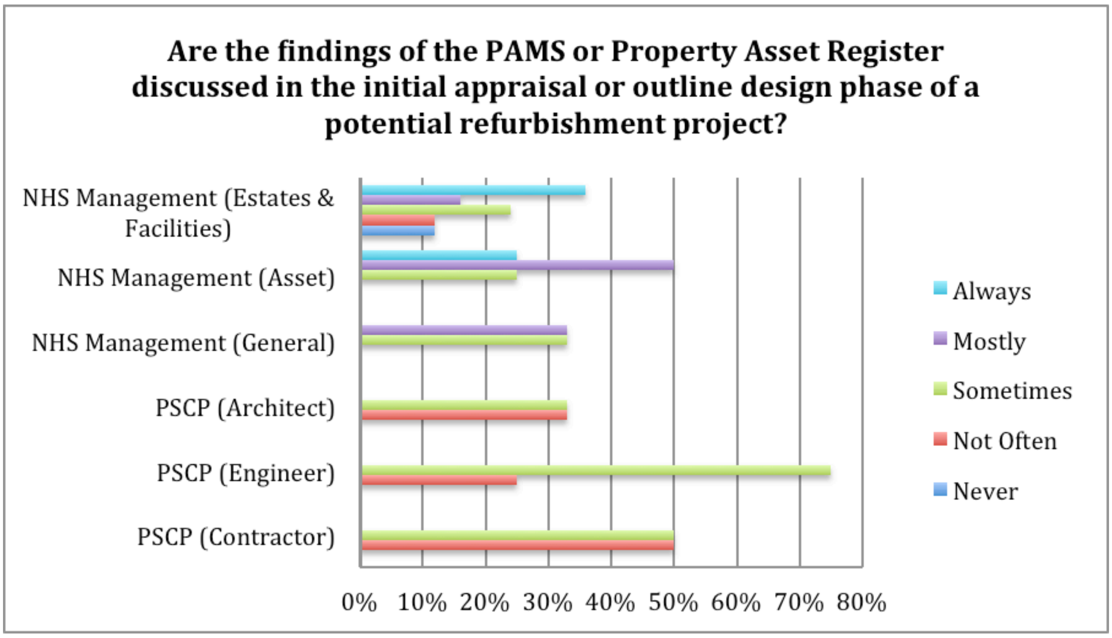


Figure 5.12. Inclusion of PAMS data in early PSCP design discussions

What the results in Figure 5.12 show, that following an seemingly continual trend, there is an immediately noticeable disparity between the responses of the two main discipline groups (NHS/PSCP). This point is measured back to the chapters introduction on the chosen methodology in the way in which the results would be presented. As a reminder, the over-arching intention was to collect, evaluate, and analyse, the findings of the integrated sample frame. This deliberate methodology being chosen to reflect the integrated nature of the entire process and its participants. It has been demonstrated however, that in regards to some of the results, further filtering ahs been identified as essential to provide a more detailed picture. The findings here, indicate that there is a disconnection or communication 'grey area' on what and how the property based issues are discussed at the transitional phase from PAMS to SCIM. As discussed previously; key positives of using MCDM include the measured consideration of relevant criteria and options. If the PSCP does not (in the main) consider the PAMS document and its prioritised issues to be present within (or at least a meaningful part of) the early design discussions, then it may be inferred that this is the 'weak link' in the process, which ultimately directs the research to identifying 'the gap'. This area of communication weakness however, may also be viewed as the area of 'opportunity', as this is where the Multi Criteria Decision Making Process is best seated on the process continuum. The literature review, and the models development chapters, identify the key requirement for a process of identifying, filtering, and selecting the initial decision criteria, and subsequent options. The data recorded throughout the NHS property appraisal process, and the information and specification requirements that are needed from the outset of the SCIM process, support the integrative potential and the compatibility of using MCDM techniques within the existing (albeit, often fragmented) processes.

5.4.3 Can the use of MCDM modeling techniques, demonstrate that Value for Money has been achieved as far as reasonably practicable, specific to the project in question?

This research question differs from it's predecessors, in respect of the fact that it is far less tangible in regards to seeking a definitive answer. Facets of the question are discussed throughout the questionnaire response, and also the previous research questions (MCDM applicability, defining Value for Money etc.) There is no significant body of research in the academic literature, which matches and discusses any clear and solid connection between MCDM techniques, and demonstrating Value for Money (particularly in regards to the capital investment process relating to healthcare refurbishment). Therefore, in the context of secondary data collection by means of the literature review and study of the technical guidance, there is no credible way to answer this question. Even in the primary data collection, the responses collected from the questionnaire, and comments from meetings with discipline professionals gives no clear indication on whether MCDM techniques can demonstrate Value for Money. To this end, the question is rhetorical in nature. What it does prove however, is that the best way to seek an answer will be through the prototype testing phase, whether this be on a live case study, or a workshop setting. In this case, this will be revisited and discussed in the results section of the model development and prototype testing chapters and sections, respectively.

CHAPTER SIX DEVELOPING THE PROTOTYPE

6.1 Introduction

The prime objective of the research is the development and validation of a Decision Support Model (DSM) *prototype*. Both primary and secondary data collection exercises, recognise the potential benefit in the development of a user-friendly, integrated, and flexible model, which has capacity to interact with the current business case models and asset management processes. Throughout; the prototypes development has required assessment and measurement against current practice and challenges (especially in respect of sustainability requirements) This has necessitated a layered approach to the construction of the prototype (Figure 6.1)

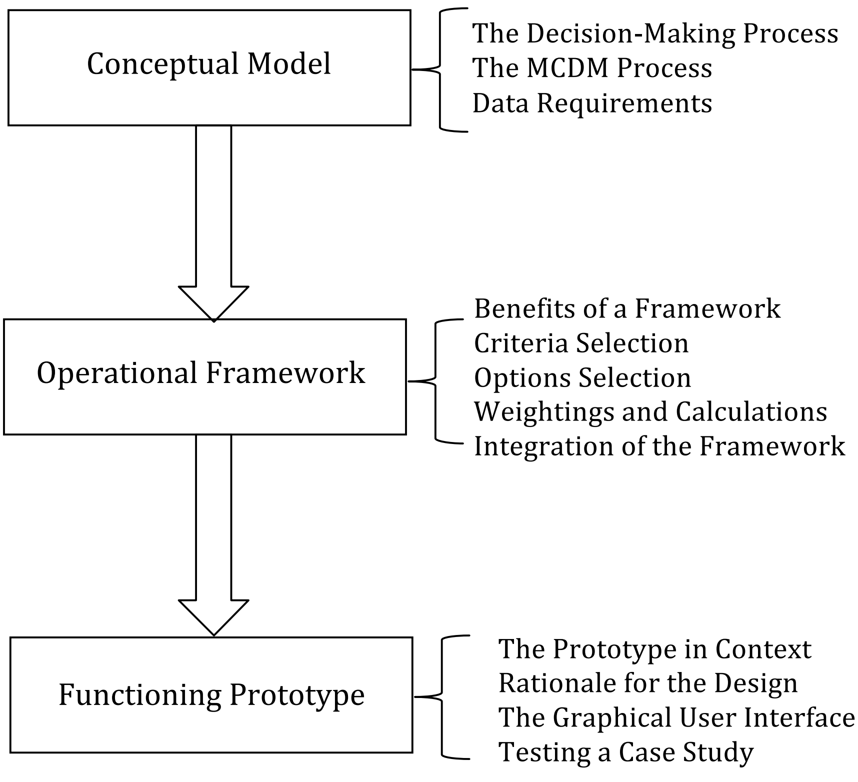


Figure 6.1. Layered development of the DSM from concept to prototype.

Aside from the criticality of identifying and allowing the inclusion of the required data requirements, as advised by Al-Hajj (1991) the challenge for the development process was to incorporate a relevant and applicable MCDM methodology, and establish a physical medium in which to apply these principles to sustainable refurbishment of hospital and healthcare facilities. Additionally; value was identified in utilizing a software platform, which is familiar to the potential user, and fully compatible for use with the existing NHS Scotland asset management systems.

6.2 Development of the Conceptual Model

The conceptual model is, by its nature, the philosophical and academic underpinning of the complete Decision Support methodology. There is, to some extent, a process of *reverse engineering* required in developing the conceptual model. This challenge of building in reverse is referred to in more detail in the central *framework development* section, in terms of three and four-dimensional attributes to the developing frameworks components (when gauged against current systems and processes). The importance of a robust conceptual model is recognised across disciplines, notably by Lucas et al (2013), who highlight the requirement to assess early accessibility, data requirements, and usability.

6.2.1 The Requirement for an MCDM approach

The literature review identified the hospital (and this term will henceforth include all 'healthcare facilities') as a unique and highly complex facility. When the uncertainties of the refurbishment process are added to this, the proposed project is already starting from a position that has many inter-related, and often conflicting, criteria. This 'multi-criteria' starting point presents a logical progression to the use of multi-criteria decision modelling (MCDM) techniques. Loken (2005) makes the point that the Decision Maker (DM) is primarily concerned with finding the 'optimal solution', which may only really be possible if measured against a single criterion. The volume of financial and technical considerations within the refurbishment process makes this completely impractical. Triantaphllou (2000) recognised this and highlighted the key advantage of MCDM which seeks to ascertain the 'best alternative' when presented with multiple sets of decision criteria. Bouyssou (2000) captures the over-arching essence of decision making techniques in describing them as…

"A set of explicit and well-defined rules to collect, assess and process information in order to be able to make recommendations in decision and/or evaluation processes"

Although Bouyssou et al (2000) clearly recognise the limitations and imperfections of any 'single' MCDM method, a process of 'weighted evaluation' is proposed as the most practical and inclusive, given the nature of the refurbishment issues, and the composition of the DM team. The critical mechanic of this system, is the comparison of 'every' criteria, against 'every' criteria, which are subjectively ranked, as suggested by Kirk and Dell'Isola (1995) which then allows alternatives to be developed in weighted terms. Although founded upon mathematical principles and expressions, a key characteristic of the weighted evaluation methodology, is that it may be expressed in very simple terms, and also be flexible enough to allow integration to the existing NHS tools and systems. This point was highlighted as being a key success factor of any model development by interviews with NHS asset management professionals (see 'Results and Analysis' chapter).

6.2.2 Selecting MCDM techniques over existing assessment methods

There are a vast number of sustainability assessment methodologies, many of which have the flexibility or version to accommodate hospitals and healthcare. Similarly there are many that are focused on, or amenable to the challenges of the refurbishment process. However, there are few which capture the refurbishment process as an activity, and the targeted functional requirements of healthcare facilities as a combined approach. The NHS is restricted to a relatively narrow choice of assessment methods as part of the funding approval processes, guided by the capital investment procedure within the HM Treasury Green Book 'Appraisal and Evaluation in Central Government' (2011). This in turn is the main reference document for the Capital Investment Manual (1994) and the more recent Scottish Capital Investment Manual (2010). The majority of the NHS building works are subject to Building Research Establishment Environmental Assessment Method (BREEAM) assessment, the Achieving Excellence Design Evaluation Toolkit (AEDET), and reference to the Activity Data Base (ADB). Other methodologies have been adopted, albeit on a far smaller scale, such as the Leadership in Energy and Environmental Design (LEED) system, and many of the smaller value refurbishment projects are in fact, ignored completely. Although these systems 'do exist', it is a widely held view within industry that they are not suitable for application to hospital refurbishment. This perception is supported by the Building Research Establishments (BRE) withdrawal and ongoing redevelopment (in 2012) of the BREEAM Healthcare (Refurbishment) assessment. As effective (or otherwise) as these methodologies may be, there is one fundamental difference when compared against the MCDM technique. To achieve a set 'rating' score, almost every method provides guidance on specification and element or component selection. However, and critically, there is no process of deriving the best specification or design alternative based on a weighted, calculated, and measured selection process. Given the complex nature of the hospital refurbishment process, and as stated earlier, the challenging economic and regulatory parameters, it seems evident that a model which has the capacity to prioritise specification choices and design decisions would be of great benefit to the client and design team at the early planning and outline proposal stages. The capability of extracting the subjective expert judgement of the design team and the clinical and operational requirements of the client, and then enabling an objective prioritised system of 'trade offs' to be established 'specific to the facility in question' will be of great value to the project delivery. This value is in turn measured against value for money and the requirement to attain the functional and sustainability standards required by the facility and the wider NHS.

Drawbacks and Limitations of the MCDM process

The potential for using MCDM techniques, and the value of doing so has been discussed. However, notwithstanding the benefits of quantifying and prioritising the vast amount of possible criteria, Trianttaphllou (2000) identifies what he terms the 'decision making paradox'. This paradox recognises that given the sheer number of existing and continually developing models, the only true way to establish which method to use is by means of a multi-criteria decision making process. The looped impossibility of this scenario highlights the fact that ultimately, the decision making process is founded on a subjective platform. This seems contrary to the objectives of many of the methods used. The 'criteria' itself, which are naturally the backbone of the MCDM process present their own limitations. The MCDM process cannot be considered as a 'black box' which will provide ready made solutions. The end result is only as good as the quality and relevance of the data or criteria that is fed into the model. Zavrl et al (2009) expand on this point in recognising that the criteria itself is governed by its ease of availability, or as modeled by Braunschweig et al (2001) the criteria selection process follows 'generation', to 'relevancy', and finally 'applicability'. This may seem straightforward enough, but caution must be observed in understanding whom the parties are that select the criteria. The clearest example related to this research, is the identification of the intended model user groups (as identified within the population sample of the main primary data collection exercise), which essentially divide into NHS professionals, and PSCP professionals. This limits the criteria to that which is prioritised by these respective expert groups (and the disciplines within them) and could, it may be argued with some validity, create limiting parameters to the models results.

6.2.3 Rationale for the Conceptual Design

It is crucial to understand from the outset, the composition and relationship between the processes and phases of the act of *making a decision*, and the integration of the MCDM techniques and component parts. At its most fundamental level, Zarghami & Szidarovszky (2011) identify the three core components of any decision making process as the decision makers, the decision alternatives (or 'options'), and the resultant consequences of the decision. Focusing on the 'options', there are two key aspects to consider. The first is the composition of the *decision space*, which is essentially the term denoting the aggregation of all of the *possible* options within the decision model. In respect of the research prototype (and supported from qualitative data collection), the decision space is designed to accommodate a *discrete* (finite), number of potential options as opposed to a *continuous* (or potentially infinite) range of choices. The second aspect of the characteristics of the 'options' are that they are measured by the presence of *criteria*, which signify, as stated by Zarghami & Szidarovszky (ibid), how well the option can be gauged as being successful or useful. In essence, 'criteria' in this context, may be categorised as issues that are *important to the decision maker*. The logical culmination of the options and criteria relationship within the overall MCDM process are captured in Table 6.2.3a.

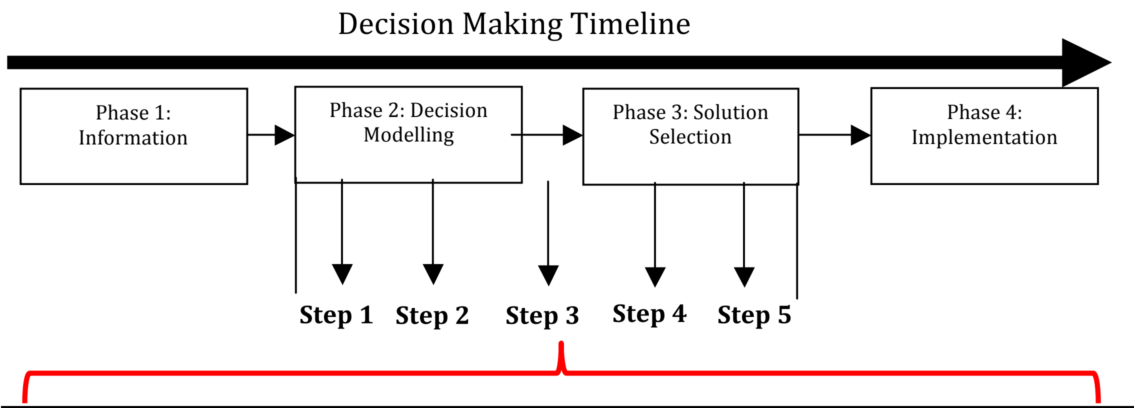
Step	Activity
1	Identify Goal (and Objectives)
2	Identify Criteria
3	Identify Alternatives
4	Alternatives/Criteria Evaluation
5	Make Decision

Table 6.2.3. Five step MCDM process (adapted from Zarghami & Szidarovszky 2011)

It is instructive to re-emphasise the clear advantage for the continuous decision space with its potential computational ability, although the argument for a discrete approach is that the model discussed within this research deliberately seeks to avoid unnecessary mathematical complexity and balances this against the goal of still presenting a multi criteria decision making process which is 'fit for purpose'

The MCDM process shown in Table 6.2.3a is however, only a part of the overall decision-making process. The five-step process may even be regarded as the technical aspect of the conceptual model. To provide context, this technical process must be framed within the wider decision-making process itself. Zavadskas et al (2008) propose a definitive four-phase process for doing this. Figure 6.2.3b shows this process with the five-step MCDM process integrated within the relevant phases. It should be understood that each of the first three phases shown in Figure 6.2.3b, demand decision making processes within their own right, and this will be demonstrated in the ensuing sections of the chapter. Phases 2 and 3 are viewed as the heart of the actual decision-making process, and multi-criteria decision modeling (MCDM) techniques are applied using the five-step MCDM process (Table 6.2.3) discussed earlier.

In summary, it can be seen that steps 2 and 3 are the key filtering and calculation processes which identify and measure the subjective information input, and assign weightings where required (Step 4) that allow a quantitative and measured solution (or output). A key objective of this methodology is to consider the discrete options that are specific to the facility undertaking the refurbishment process.



Step	Activity
1	Identify Goal (and Objectives)
2	Identify Criteria
3	Identify Alternatives
4	Alternatives/Criteria Evaluation
5	Make Decision

Figure 6.2.3 Four phase decision making process showing the integration of the 5 Step (S) MCDM technique (adapted from Zavadskas et al 2008 and Zarghami & Szidarovszky 2011)

6.2.4 Developing the Conceptual Phases

Although it is recognised that the 'whole' decision support model is an integrated system, the 4-phase approach described above has distinct interface points. The simplest means of identification for the observer, is to understand that the final activity within each phase provides the required level of information to generate the first activity of the following phase. This is most clearly seen in the transition from phases 1 through 4. Figure 6.2.3b shows the conceptual model in its holistic form, although the final intended output (or *the prototype*) is characterized (in the main) by the 5-step MCDM process described. This characterization is in relation to the actual mathematical mechanics of the decision making process, although there are fundamental data requirements which must be considered within each of the first three over-arching phases. The data requirements themselves are, to some degree, dynamic, in the sense that the model requires to possess flexibility in the selection and measurement of the relevant criteria and options. This is supported by the findings of the literature review, a powerful example being Braunshweig et al (2001) observation that decision makers…

"…have to know the critical issues involved and these are usually veiled at first"

This is a significant point to understand, in that the decision making process and associated MCDM techniques are by no means intended (as previously discussed) as a 'black box' or 'quick fix' resource. On the contrary, a measure of professional subjectivity is encouraged, or more correctly, *essential*, in considering the hospital on an individual, case by case basis, as opposed to a 'one size fits all' methodology. Triantaphllou (2000) recognises the impracticality of considering every possible criterion and alternative with the key observation that MCDM is concerned with seeking the 'best fit' or 'trade off' result when faced with such a potentially vast range of possibilities. In this context, the conceptual model is directed to focus on the methodology of the overarching decision making phases shown in Figure 6.2.3b, and a set of indicative or generic data requirements to populate the range of variables in each described 'step'. On this basis, each conceptual phase and integrated step is described below.

6.2.4.1 Phase 1: Information

Despite this sections objective of building and validating the 'conceptual' model; each of the four phases must be framed in the context of the current capital investment process. It is understood that phases 2 and 3 (Figure 6.2.3b) can be considered in terms of the actual mechanics of the decision making (and MCDM) process. Phase 1 however, has no identified steps within it, although it is an obvious necessity that for the decision making process to be undertaken, the steps identified by Zarghami & Szidarovszky (2011), and the data requirements for each, must be created from information inputs. This approach outlines the future shape of the developed framework, and in conceptual terms, uses high level actions and activities associated with the early property appraisal process (Figure 6.2.4.1)

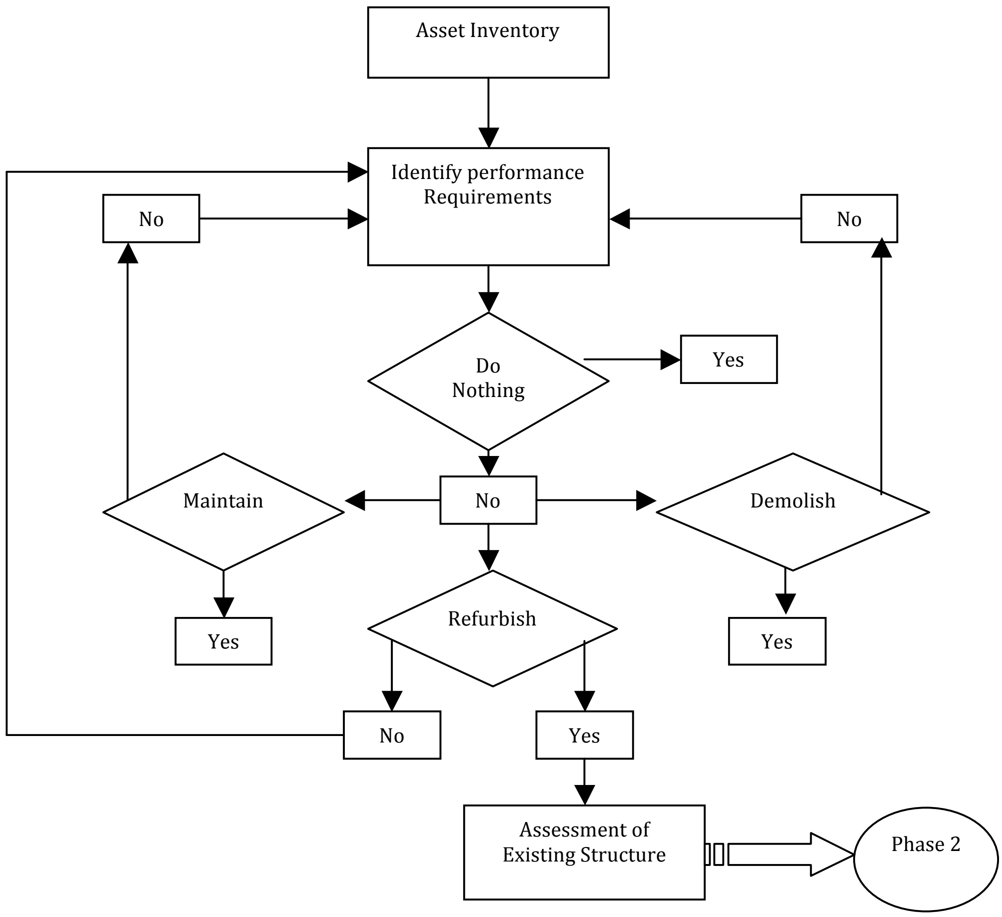


Figure 6.2.4.1: Phase 1. High level information inputs

A condition (or asset) survey is vital from the outset, and is shown on an estates level within Figure 6.2.4.1 as an 'asset inventory' followed by an appreciation of the required 'performance requirements'. Selih (2007) recommends the asset inventory as 'key' in establishing the performance requirements of the building under consideration. She especially highlights the requirement for using a pre-defined assessment methodology, and this is met with the NHS Scotland's own asset management processes by means of the Property Appraisal Guidance discussed in the literature review, and considered as a component of stage 2 of the model development process later in this chapter.

6.2.4.2 Phase 2: Decision Modelling

It is within Phase 2 of the overarching process, where the first elements of the five-step MCDM process begin. Although they may be used interchangeably; the terms 'goal' and 'objectives' are separated (respectively) into essentially higher level, and more detailed level components from which the overall goal is pursued (Figure 6.2.4.2)

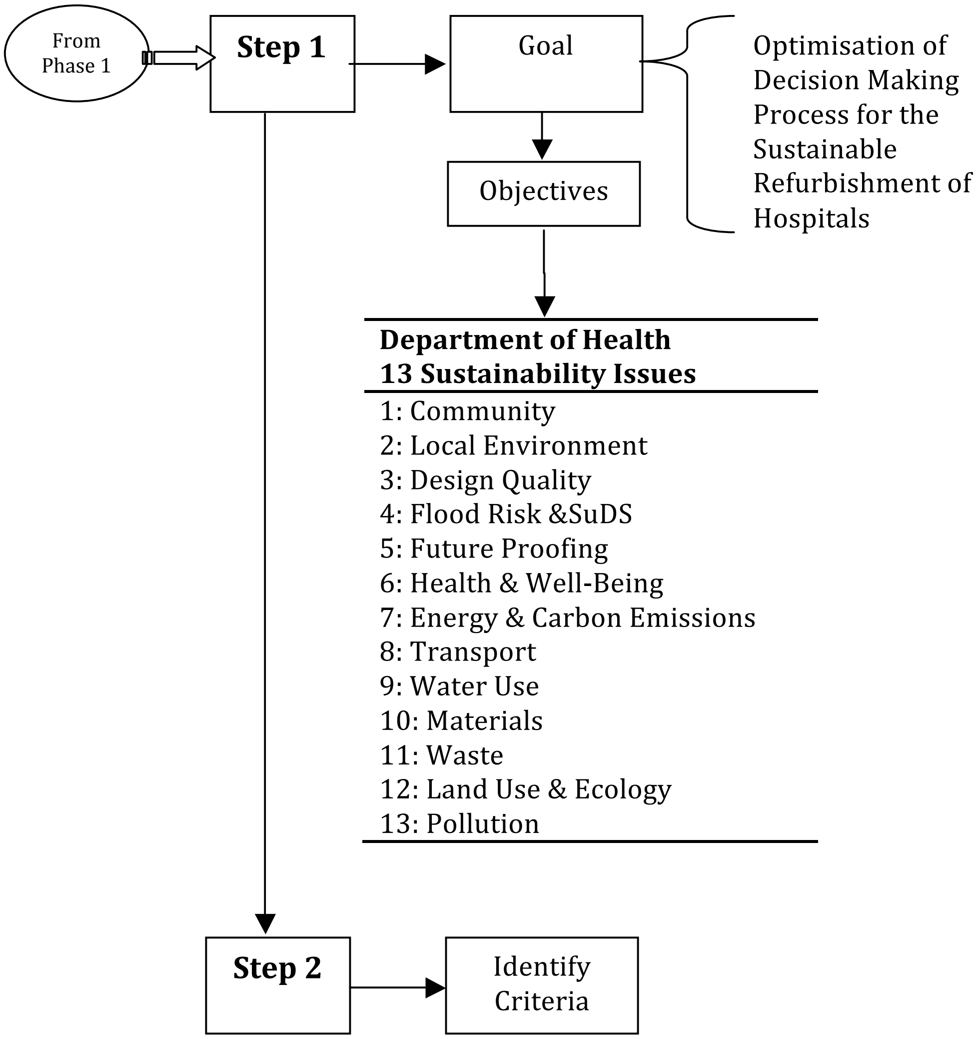


Figure 6.2.4.2: Phase 2/ Steps 1 and 2 (Issues adapted from HTM 07-07. 2009)

The combination of Steps 1 and 2 are logically placed within the overall Decision Modelling phase (Phase 2) Although the Steps themselves are generic, Figure 6.2.4.2 clearly demonstrates the higher objective 'goal' and the objectives (in the context of 'subject areas') required in attaining it. The objectives, which in this case, and for the purposes of demonstration, are the Department of Health's (HTM 07-07. 2009) own 13 sustainability issues, are also the first layer of 'main criteria'. Each issue is independently considered by means of the process shown in Step 2. It may even be accepted that Step 2 is the generation of 'sub-criteria', and the filtering and selection process applied to suit. The key aim at this point, is to identify a discrete number of criteria for consideration against future possible alternatives.

Data Requirements

It has been established that the starting point in building an MCDM model is to establish the main evaluation criteria and the relevant sub-criteria, which will in turn allow for the subsequent mathematical construction of the weighted and ranked model. The research utilises Braunshweig et als (2000) reduction method (Table 6.2.4.1) to allow the subjective recognition of the relevant sub-criteria by the decision maker

Generation: Initial set of Criteria	Relevance: Potential set of Criteria	Applicability: Final set of Criteria
Legislation Codes of Practice Health Technical Memorandum Health Building Notes Clinical Output Specification BREEAM/AEDET Standard Checklists	Relevance to Project Measurement Duplication Goal Conflicts Importance to Project	Availability of Data Measurability of Data Ambiguities Evaluate Applicability

Table 6.2.4.1: Reduction method in identifying the data requirements (adapted from Braunshweig et al. 2000 and Kishk et al 2004)

The 'Criteria' are defined by the Oxford English Dictionary (2010) as:

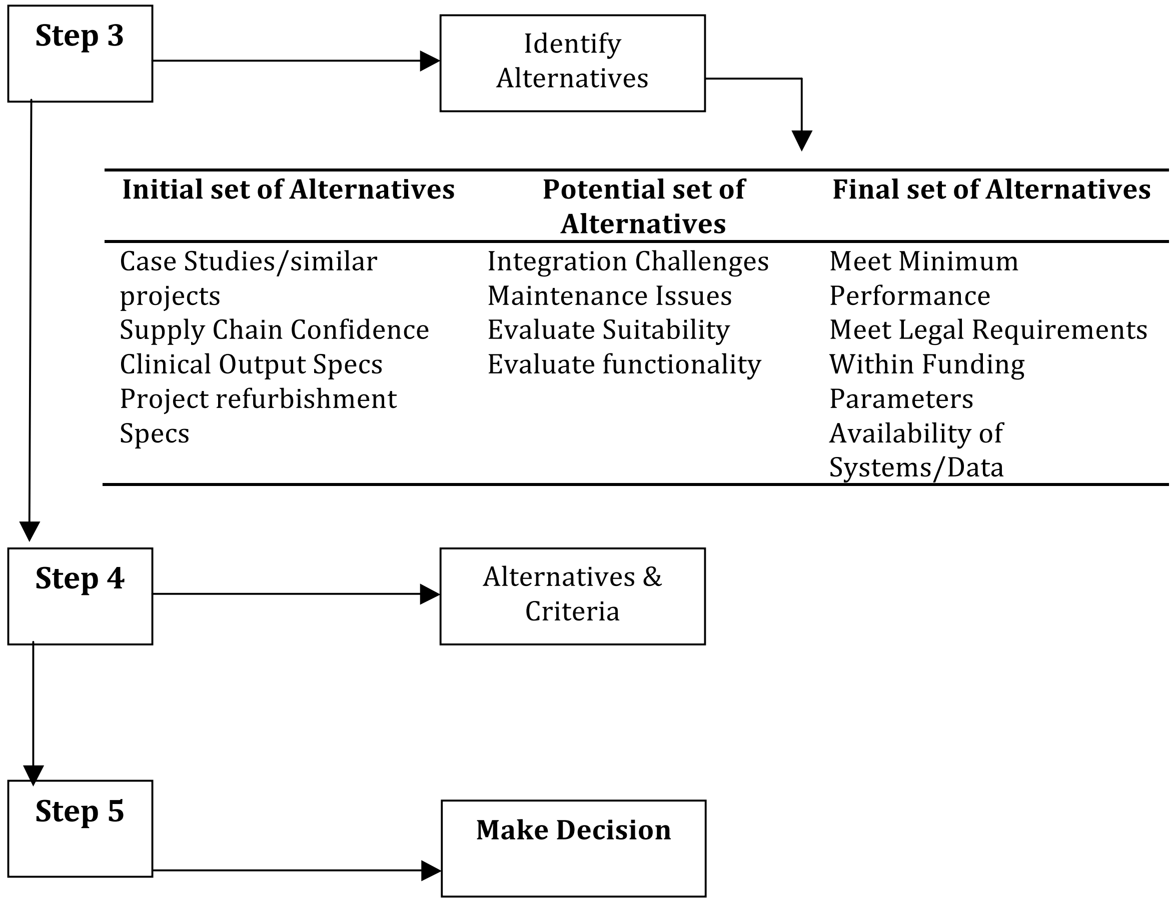
" a standard by which something may be judged or decided"

This most basic of understanding is an essential aspect of the criteria identification and selection process. The possible number of criteria which may be added to any decision making process are absolutely vast, so the fundamental and targeted recognition of exactly 'what' is being selected as the most relevant and pertinent to the subject matter is vital. This reinforces the first step in the wider process of creating the model, which stipulates that the first necessary action is to 'identify the problem goal'.

Kishk et al (2004) present an adapted version of Braunschweig et als (2001) triple phased selection process which takes a filtering down approach to select criteria so that the end result is a very specific and relevant set of results. The process is a very logical one, and the intention is not to attempt to capture *all* of the criteria pertaining to the issue, but to include the smallest number of criteria possible which nevertheless still captures the highest number of relevant facets.

6.2.4.3 Phase 3: Solution Selection

Steps 3, 4 and 5 of the MCDM process are encompassed within phase 3 of the decision making process, and it is proposed that all 3 Steps comprise the 'Solution Selection' and must be viewed as very much an integrated process. There is an element of step 3, which acts as the 'bridge' between *Phases* 2 and 3, although this has some elasticity in its positioning, in that it has elements of both Phase 2: Decision Modelling, and Phase 3: Solution Selection, and may be considered on a sliding scale, dependent upon the specifics of the project information, and the techniques employed by the individual decision making team. Braunschweig et als (2000) 3 phase generation process is again employed, following Kishk et als (2004) adaptation of the same in filtering and selecting the feasible alternatives. These steps of the model undertake a process of *pairwise comparisons* to compare 'each' criteria against 'all other' criteria. This *weighted evaluation* assigns the final weight of importance and will be clarified within the framework development section. The alternatives are then considered and rated to score how the decision maker assesses the level which each alternative meets the criteria's weighted values (Step 4) This will allow for objectivity to be introduced into the decision making process by means of a simple matrix. Sensitivity Analysis may then be undertaken to prioritise and address any additional constraints not already considered within the generation of alternatives.



Initial set of Alternatives	Potential set of Alternatives	Final set of Alternatives
Case Studies/similar projects Supply Chain Confidence Clinical Output Specs Project refurbishment Specs	Integration Challenges Maintenance Issues Evaluate Suitability Evaluate functionality	Meet Minimum Performance Meet Legal Requirements Within Funding Parameters Availability of Systems/Data

Figure 6.2.4.3: Phase 3/ Steps 3, 4 and 5 (Alternatives generation adapted from Kishk et al 2004)

Data Requirements

A similar process of establishing data requirements is undertaken as that demonstrated in step 2 (Table 6.2.4.1) In undertaking a reductionist approach to the identification of a discrete number of alternatives (or options) a logical methodology is applied. This is discussed above in Kishk et als (ibid) adaptation of Braunschweig et als (ibid) selection process. Carrying the data requirements over into step 4 is done (in part) by the activities and processes described in filtering and identifying the relevant criteria and alternatives respectively. The additional data requirements for step 4 are more heuristic in nature, as this is the key stage of the MCDM process, whereby the decision making team consider the collected (quantitative) data required from steps 1 through 3, and apply consensus techniques (qualitative) to introduce expert subjectivity into the process. It is within step 4, where the developed framework must allow a mathematical process that allows this process to happen, and fuse the quantitative with the qualitative, and the objective with the subjective.

6.2.4.4 Phase 4: Implementation

Arguably the simplest phase in *decision-making* terms, the implementation phase takes the decision maker to the point where he/she may begin to specify elements, components or materials. In the *physical reality* however, the implementation phase may be far from simplistic. It should be noted at this point, that when an alternative has been selected within the system described using the completed prototype, the exact same process might be undertaken to derive the best specification choice within the given alternative. A random example to describe this might be that the alternative selected in Step 5 (phase 3) may suggest the most beneficial (and trade-off considered) action would be to insulate an exterior wall (essentially a definitive 'action'). The range of insulation types would then need to be considered as would the insulation thickness which (again) meets the 'best fit' scenario when considering variables such as energy efficiency, emissions reduction, price of materials, cost of works etc. The embedding of the consideration of insulation type within the overall insulation process itself, might even be considered as a 'sub-action'. This hierarchy is indicative of the models function as a whole, and is not necessarily restricted to element and component specification, but has potential to be adapted with ease in application from entire system, to micro-component level. This is a key advantage of using a self-replicating rule-set and methodology in the context of such a multi-faceted and complicated issue as the healthcare estate, in that a model may be used with the exact same methodology, to model the results of itself, and so on.

Although not necessarily a functioning component of the MCDM process (and the prototype itself) the Implementation phase must also be considered within the overall Business case. This highlights the criticality of identifying the correct intervention points to introduce the model to the capital investment route and/or subsequent Public Private Partnership (PPP) route selected. Once the decision-making requirements reach the contractual and procurement phases, there are obvious benefits and necessity to ensure that the correct parties are involved in the criteria and alternatives (options) selection and evaluation. This in turn demonstrates the iterative nature of the 'utilisation' of the decision making model itself throughout the planning and delivery, and the potential to reconsider the final alternatives by revisiting and sensitivity testing the criteria and variables.

6.3 Development of the Operating Framework

Stage 2 of the high-level model development methodology described in the introductory section of the chapter, has the objective of developing and proving a mechanism that allows the conceptual model (stage 1), to be transposed into the software based prototype (stage 3) In this context, the construction of the framework may be viewed as the 'interim stage' of the prototypes development. The most effective, and inclusive, means of doing this is by the construction of the aforementioned *framework* designed to allow fusion of the conceptual design to the functioning prototype and related Graphical User interface (GUI). This 'interim stage' approach is supported by Fayad et als (1999) definition of a frameworks utility, as being…

"…the skeleton of an application that can be customized by the application developed"

It is this 'customization' capability, which offers the flexibility of fusing the concept with the reality, the quantitative with the qualitative, and the objective with the subjective. Sheth (2012) reinforces the benefits of a framework approach in identifying the implementation drivers within the construction industry, namely in areas such as time and cost reduction, resource management, improvements in quality, and (notably), the achievement of sustainability targets. Sheth (ibid) further highlights the benefits of developing and using a robust framework which have been adapted and modified to support and validate the usage within the research (Table 6.3)

Main Benefit	Breakdown of 'sub' (additional) Benefits
Comprehensive	• Clarity • Accuracy • Descriptive Aspects
Flexibility	• Adaptability • Facilitation Potential through Life-Cycle
Ease of Use	• User Customization to Specific Project • User Friendly • Simplified Interface Possibilities
Compatibility	• Compatibility with Existing NHS Systems • Logical Interface with Asset management Processes • Consistency in Results •
Affordability	• Non-Labour Intensive • Output adds Value to the Project

Table 6.3. Benefits of adopting a Framework approach (adapted from Sheth 2012)

6.3.1 Designing the Framework

The physical design of the framework is required to accommodate the core five-step MCDM process suggested by Zarghami & Szidarovszky (2011), as this process is a fundamental plank of the conceptual model. It is critical therefore, that objectives, criteria evaluation, and a form of 'optioneering' are essential attributes. The knapsack model suggested by Allane (2004) offers a basis for understanding and positioning the relationships between the criteria in the context of establishing a set of parameters.

The knapsack model is relevant in terms that it is essentially a decision making process which is undertaken with regard to recognised constraints within the variables. Also referred to as *combinatorial optimisation*, the essence is for the decision maker to consider the weighted/valued criteria, and optimise their integration and/or selection within a recognised over-riding constraint. The constraints within the prototype, being the actions undertaken as part of the alternatives/options selection process. It is therefore self evident, that the system of decision-making in this case, is also a process of trade offs and 'packing, unpacking, and repacking' of desired criteria. Allane (2004) demonstrates the over-riding constraint for her example as 'Maximum Allowable Cost'. This is framed against the acceptance that there are a number of possible actions (decision variables) to be considered where $a_1 \ldots a_i \ldots a_n$ are the possible actions and, a_i = 1 if action a_i is carried out, otherwise a_i = 0.The objective function indicates how much each variable contributes to the value to be optimised in the problem, and in this case can be expressed as:

$$MAX \sum_{i=1}^{n} a_i s_i$$

Where s_i = utility score achieved by selecting action a_i

Given the nature of the decision to carry out the action, or not to carry out the action as per the 1 and 0 values given above, it is logical that the problem will be subjected to at least 2 constraints. These being:

$a_i \in$ $a_i \in \{0,1\}$

Referring again to Allanes (2004) use of 'Maximum Allowable Cost" as the over-riding constraint, it can be expressed that:

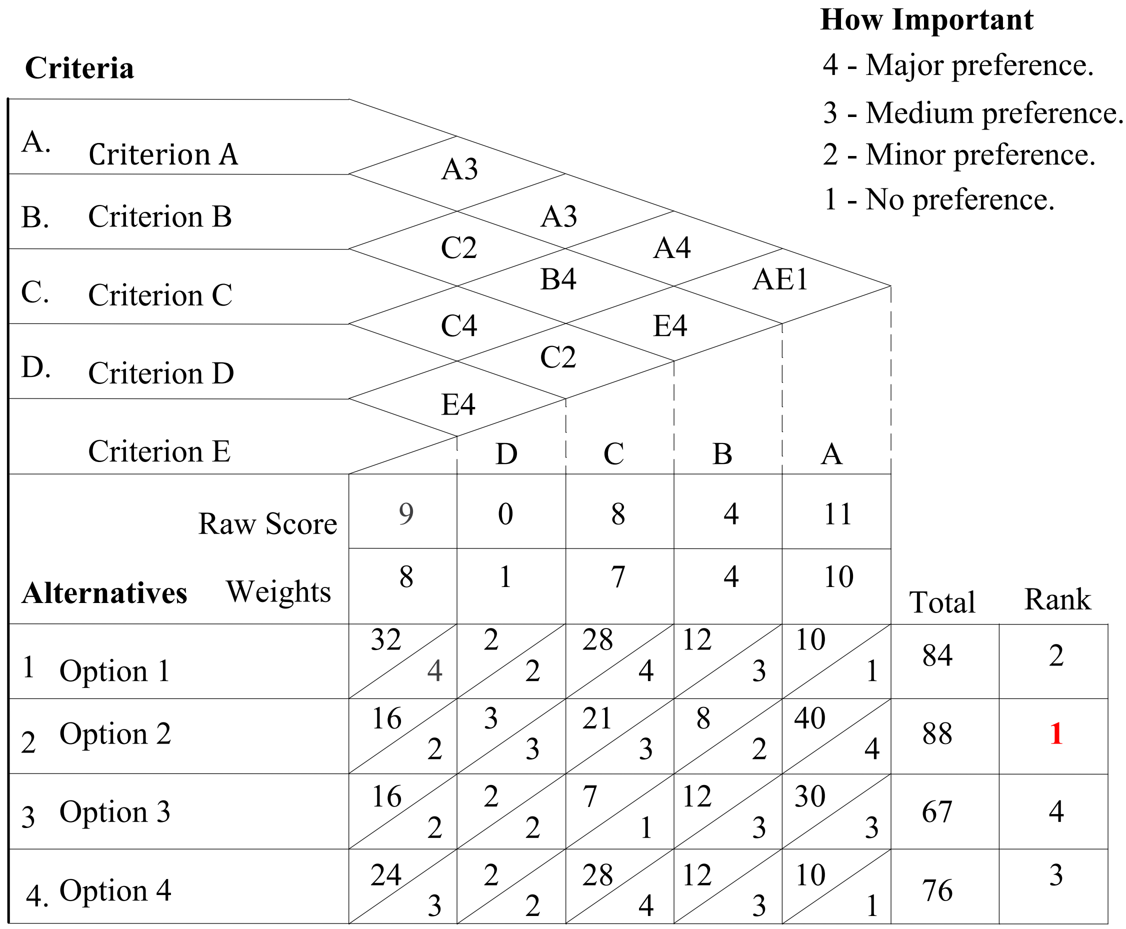
$$\sum_{i=1}^{n} a_i C_i \leq C_{MAX}$$

C_i

Where C_i is the cost of the action, and C_{MAX} is the maximum allowable cost of the project. There is a process of filtering, when assigned a logical and measured methodology to the project specifics, similar to the methodologies discussed by Braunschweig et al (2000) and Kishk et al (2004) which follows a 'main criteria' through reduction to 'sub-criteria' which, from a methodological perspective, support the conceptual aims of the evolving model. The question arises though, as to whether the knapsack model offers enough capability in the transition of the subjective (or design team consensus) into the objective, in a manner that allows full pairwise comparison techniques to be employed, and yet retaining simplicity of use for a team of decision makers populated by NHS and Principal Supply Chain Partner (PSCP) professionals, whose knowledge and experience of MCDM techniques has been proven to be very weak, as informed by the results of the primary data collection and analysis. The *weighted evaluation* technique addresses these weaknesses and allows the mathematical expressions and MCDM processes to be simplified and facilitated in a visual and simple manner.

Weighted Evaluation

The weighted evaluation (WE) technique has been demonstrated by Kirk and Dell'Isolla (1995(and Kishk et al (2004) in terms of whole life costing (WLC) techniques. This however, presents no limitation to the use of WE for the objectives of the research aims and the prototypes function. It may even be argued with some merit, that although not focusing on WLC, the developing prototype naturally incorporates these issues within its function by means of the economic dimension of the wider sustainability model, and by the nature of the strong underpinning of Value for Money as being a key driver for the models creation and validation. Figure 6.3.1 shows the WE model in the context of MCDM techniques.



1-5 Performance Scale: Excellent - 5; Very Good - 4; Good - 3; Fair -2; Poor -1.

Figure 6.3.1a. Weighted evaluation matrix in the context of MCDM (Kirk & Dell'Isolla)

The matrix (or framework) seen in Figure 6.3.1 must be referred to the conceptual MCDM steps discussed earlier. The criteria are shown indicatively, from Criterion A though E (as per the process discussed in Table 6.2.4.1) Similarly, the selected range of options are presented as options 1 through 4 (as per the process described in Figure 6.2.4.3)

Addressing the Criteria

The relative importance of Criteria A through E are established in respect to the 'importance' ratings on a scale of 1 to 4, from 'No Preference'. To 'Major Preference' respectively. This process is clearly a process of consensus and value judgments from the decision makers is critical. It is noted however, that these value judgments may be supported (or driven) by the criteria selection process in regards to legislative, regulatory, or institutional requirements. Each criterion comparison space, is then summed to attain a 'raw score' for each criterion. The weighting process is now applied in the form of 'normalising' the raw scores. Normalisation for the purposes of the framework is given the parameter values of 1 (being the lowest weight value) to 10 (being the highest weight value). Selecting the normalisation method was considered in terms of the associated data requirements of the framework, and the objective of retaining simplification as far as possible. It is common practice for decision makers to frame the normalised scales from 1 to 100, or by adopting a process of 'adding to unity' of 1, with fractions of <1 where relevant (Selih, 2008. Shohet, 2003. Zavrl et al, 2009. Zavadskas et al, 2008) However; given the nature of the values added and derived from the matrix shown in Figure 6.3.1, it has been deemed appropriate to use whole integers only with the maximum and minimum parameters stated above. It should be noted, that the weighting process will deliberately prohibit a 'zero' value being derived in the weighted values. This recognises that the criterion selected are all, by their nature, of a certain level of importance or value to the decision maker. The process of deriving weights is a simple calculation.

This can be described by example, by considering Criterion C (raw score of 8) The maximum raw score (criterion A) is 11, which following the normalisation rule, converts to the maximum allowable of 10. To derive the weighting of Criterion C therefore, the maximum weight is divided by the maximum raw score, and the resulting figure is multiplied by the raw score being considered (in this instance, Criterion C). It is likely that the result will not in fact be a whole integer, so a simple rounding process is undertaken which uses the rule that any value < x .5 is rounded down, and anything from x .51 onwards is rounded up. This is shown in Figure 6.3.1b.

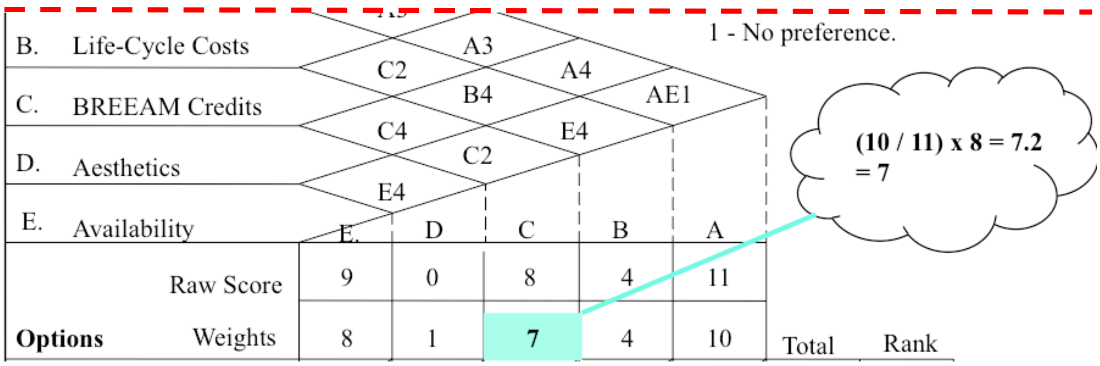


Figure 6.3.1b. The normalisation calculation

Addressing the Options

Evaluating the options is the preceding step to assigning a ranking of preference for the 'preferred option'. The process (excluding the final ranking) consists of three actions. Action 1 is the assignation of a value in respect of the 'Performance Scale' which runs from 1 (poor) through 5 (Excellent). As the scales title implies, the decision makers consider each option against each criterion, and assess a value of performance (or perceived performance) for each. This follows the pairwise comparison technique, which is the heart of the frameworks process. Action 2 sees that simple multiplication is carried out of the (now whole) integers of each weights performance score, against the derived weighting for each criterion. This derived value can be seen in Figure 6.3.1a as the higher value sharing the split options cells. This action is also the beginning of the transition phase of the qualitative to the quantitative, or the subjective to the objective. Action 3 shows that the completed scores are then summed to a raw total, and by merit of the highest value total being the most preferred, are ranked from 1 through x (dependent upon the number of options being considered) This process can be mathematically expressed as:

$$A^{*} = A_i \mid S_i = \bigvee_{i = 1_n} \sum_{i=1}^{n} W_j S_{ij}$$

If the Criterion weighting is W_i and the alternative rating is understood to be S_{ij}
Subsequently, S_i is the total score of alternative j

n and m in this case, are the competing alternative (options), and criterion, respectively. The objective being to ascertain A^* which is the alternative (option) with the highest *total* score.

6.3.2 Integrating the Framework

Before developing the functioning details of the prototype and related GUI, it was necessary to place the framework (and subsequent prototype) within the context of the wider asset and estates management processes related to NHS Scotland. This is a key consideration, and sight must not be lost of the multi-faceted approach and dimensions of the hospital or healthcare facility 'in refurbishment', as discussed within the literature review. In addition to the powerful driver that is the pursuit of a best Value for Money option, and a methodology which provides a provenance function that VFM has been considered (as far as reasonably practicable) relative to the unique aspects on a facility by facility basis. The clinical requirements must not be neglected throughout. Although in part, these are protected by means of the clinical output specification, and the myriad Health Technical Manuals, and Health Building Notes etc., the potential impact of the actual activity of refurbishment and maintenance on healthcare facilities, has been shown by various researchers to present possible negative impacts on the patient safety and ultimate length of stay and recovery rate. (Loo et al, 1996. Oren et al, 2001. Lutz et al, 2003) Critical to identifying and validating the correct 'intervention point' for the framework (prototype), is a contextual understanding of the current NHS asset management, and also 'decision making', systems and processes. This is discussed in detail within the Contextual Background chapter, however, for continuity, Figure 6.3.2a shows the high level hierarchy of the core guidance documents.

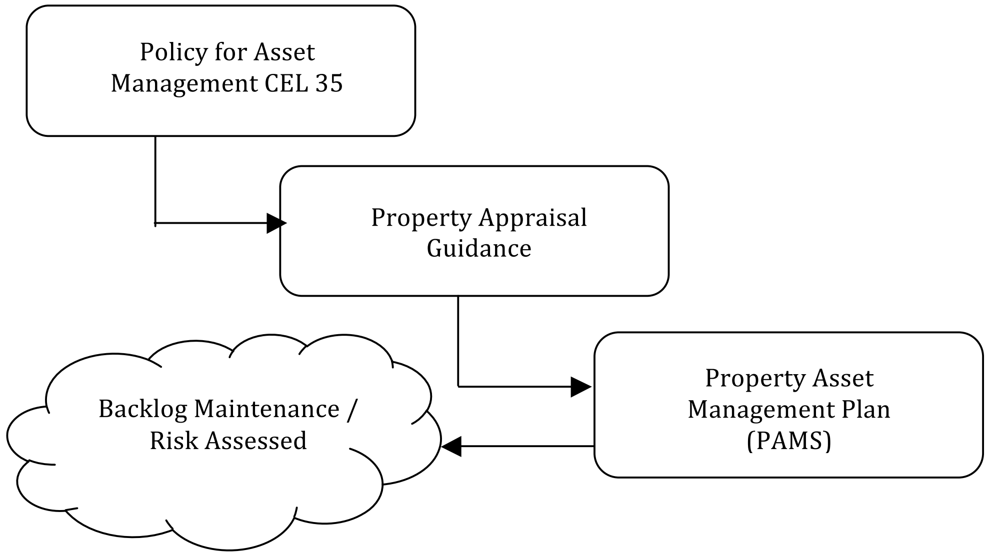


Figure 6.3.2a. High-level representation of NHS Scotland, asset management processes. The backlog maintenance 'output' relationship, is also shown.

As figure 6.3.2a demonstrates, the process is described in simplistic terms from government level (CEL 35), to NHS Board level (PAMs). Significantly, it is the 'backlog maintenance/risk assessed' output (designated within the cloud symbol in Figure 6.3.2b) that carries the decision-making process forward in to the more detailed decision making phases. Reference is again made to the observations of the Contextual Background Chapter, which discuss and explore the individual and connected issues in greater detail. There is also merit in re-emphasizing the results discussed in the 'Results and Analysis' chapter, in regards to the sample frames knowledge of the processes shown in Figure 6.3.2b. There was an unsurprising knowledge gap between the NHS asset, estates, and facilities managers; and the members of the PSCPs (who were in the main, architects, engineers, and contractors). Although critically, as the starting point (and also the legislative and regulatory guidance mechanism), the main output, as described in Figure 6.3.2b is the actual 'identification' of priority areas, and is supported by the earlier reference to Selihs (ibid) recommendation that a full asset inventory be carried out as a 'first step'. This being the case, the risk assessed backlog maintenance is carried forward to the next step, whereby the PSCPs will begin to interface with the refurbishment requirements. This opens up the framework and the prototype development to discussion in terms of the requirements of the research project itself, in identifying the 'gap in the knowledge' and exploring the 'original contribution' to the body of academic literature. Figure 6.3.2b illustrates the process in continuation from that shown in Figure 6.3.2a, and shows also, the interface, or engagement point, at which the PSCP will generally become involved with the refurbishment process.

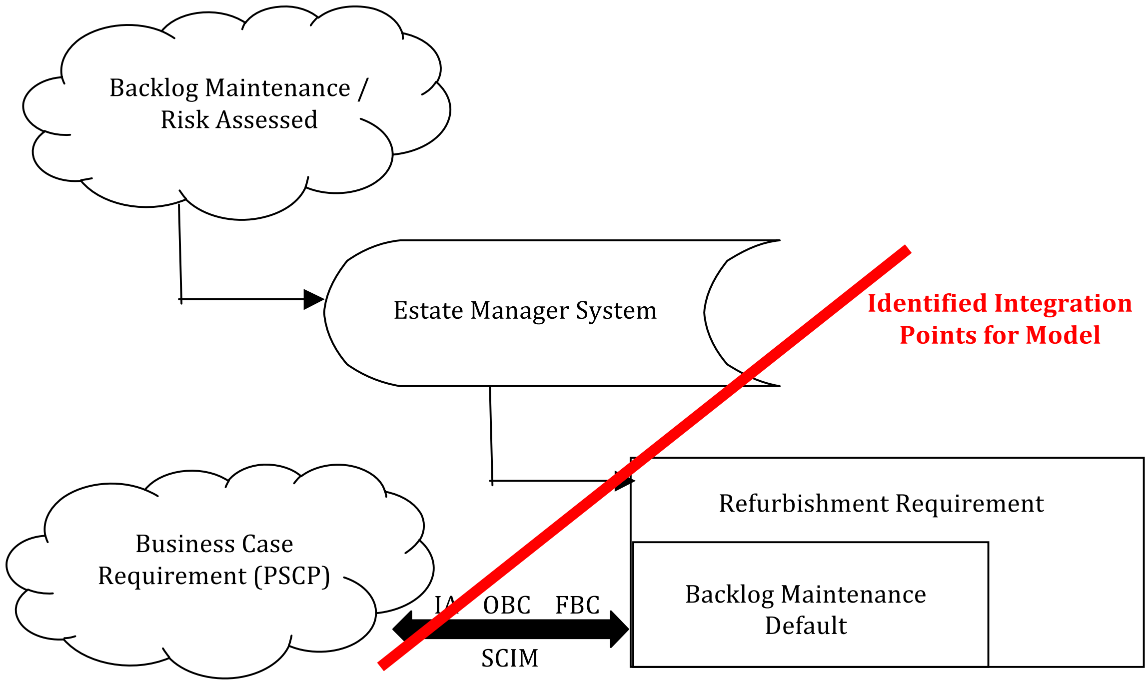


Figure 6.3.2b. Interface points of the PSCP to the refurbishment process by means of the standard capital investment business case process

What Figure 6.3.2b shows, is the usage of the NHS *EstateManager* software tool, to record the rated and prioritised backlog maintenance actions derived from the asset inventory. The significance of the 'box in a box' shows the possible default position of a planned refurbishment budget being required to incorporate the identified and costed maintenance backlog items identified within the property appraisal process. This itself, is a validation point for developing the prototype, in that if (for example) 75% of an allowable projects budget is already allocated to priority items to maintain a condition and performance rating of the facility, then an integrated design and specification approach is preferable. Figure 6.3.2b clearly shows the *integration line* as bisecting across the process. This is wholly intentional, and in fact represents the three-dimensional nature of the process when undertaken in reality. It might be more correct to identify the *four-dimensional* nature of the process, given the presence of a timeline (as seen in in the decision making process described in Figure 6.2.3a) Refocusing on the integration line in Figure 6.3.2b, the first interface occurs with the outputs of the PAMs input and the *EsateManager System* output. The risk-based methodology, which is contained in entirety within the *NHS Scotland Property Appraisal Manual* (2011) requires that the prioritised items are carried into the refurbishment process. The mechanics of this happening, require the engagement of the selected PSCP whom will engage the project by means of the standard Business Case process (as discussed in depth earlier in the report) The business case itself, must be interfaced at the correct phase for the framework and prototype to be effective, and this is identified within the early stages (namely towards the end of the Initial Agreement (IA), and the beginning of the Outline Business Case(OBC)) It is important not to confine the potential of the MCDM process (or in fact, the prototype in its developed form) to these points in the Business Case only. The flexibility of the prototype is transferable to a multitude of decision making scenarios where 'best fit' and 'trade off' methodologies are required. In the context of refurbishing the hospital and healthcare facility however (and within the limitations and mandatory parameters of the current guidance and systems), the prototype will be best served if based upon basic data requirements offered within a potential Scope of Works. The IA offers this by process of the paring down to a *short list of options*. The short list of options presents a matrix of multiple (potential) scope of works, dependent upon the preferred option selected going forward. Bearing in mind the comments above regarding the flexibility of the prototype (and in this case…potential to consider the initial *long set of options* contained within the IA), the validation example in this chapter will follow on from the agreed decision from the NHS/PSCP on what the preferred option will be, and consider the works required to the various elements and sub-elements related to the hospital and healthcare building.

6.3.3 Identification of 'The Gap' and the Original Contribution"

This has been touched upon earlier in the chapter. The 'gap' cannot be viewed in isolation, due to the three (four?) dimensional nature of the process. The gap in terms of the current process and systems is in the 'disconnection' between the outputs of the *EstatesManager System* (and the associated ranked, prioritised, and potentially costed backlog maintenance actions), and the carrying forward of the same actions into the physical refurbishment process via the standard Business Case. The secondary and primary data collection exercises support this statement, in identifying that no structured or measured methodology is employed to consider, measure, and specify, the 'best fit' option, which satisfies not only sustainability related requirements, but demonstrates that Value for Money has been pursued. The original contribution, in this context, is focused on the exploration and delivery of a facilitated decision making process, which engages the NHS/PSCP actors by a process which mines the heuristic expertise of the 'collective group'. This allows the process to be quantified and mathematically weighted to provide a range of 'best fit' options, supported and validated throughout, by the regulatory, legislative, and institutional requirements *specific to the facility in question*.

6.4 Development of the Functioning Prototype

The final step in the development of the prototype, naturally focuses on the development, and testing, of the processes built upon throughout the conceptual and framework development stages. Key to this, is the application of the decision making process through means of a simple, and user friendly, Graphical User Interface (GUI). Selection of a software platform was a priority consideration. Critical reflection identified four main (desired) requirements. The platform must posses:

1. Capability: Given the types of calculations and the range of data entry requirements, the software must have the capacity to undertake the actions and background programming requirements.
2. Integration potential: The flexibility to integrate with existing NHS Estates Management systems.
3. Familiarity: By recognising the intended user groups of the completed model, a platform that is (to a large degree) already familiar to the user groups.
4. User friendliness: Ultimately, the GUI must be simple to understand and simple to use. A platform that allows for the majority of the

calculations and formula to be hidden and presentable to the non-expert user.

6.4.1 Selecting the Software Platform

The Microsoft Excel® platform was identified as the appropriate platform in addressing the above listed criteria. In respect of the discrete characteristics of the criteria and options selection outlined in the previous section, the capability and performance of the platform proved wholly adequate, and as recognised within the 2010 Excel Bible (Walkenbach 2010), the software is capable of a large and varied range of calculations, the automation of complex tasks, and critically, the ability to create graphics and diagrams which are dynamic in regards to the changes made to data entry. The secondary data collection exercise, and discussion with the current developer of the NHS Estates Management systems, identified Excel as being the foundation platform for the tools currently in use. Therefore, in anticipation of potential integration of the prototype within the current systems, it was desirable to retain the same programming format. In terms of familiarity, the primary data collection demonstrates an overwhelming response that Excel is the most commonly understood, and widely used, software platform, when compared against other software that carry out the same or similar functions. This supports the tacit understanding, that the Microsoft Office® package, is the dominant core software works package used across industries, and certainly within the UK construction industry and the NHS. Although the actions and possibilities to change the prototype template are restricted through the use of macros protection, the GUI is nevertheless a modified set of worksheets that will be familiar to the normal Excel user. The user-friendly aspect of the model may even be considered as one of *the* most important aspects. An overly complex GUI may have the capacity to contain more information, and to offer a greater range of functions, however, following the discrete approach philosophy to the decision making process in general, a 'less is more' approach was pursued as a priority. This also reflects the comments from PSCP/NHS professionals throughout ad hoc interviews who were emphatic in highlighting the potentially negative reception of…"yet another complicated management tool" and comments which offered the light hearted warning, that a model that was visually and practically complex would most likely find its best use in the project office of…"propping up the leg of a wobbly table". Despite the levity, this fact cannot be overlooked or taken lightly, as regardless of the capability and utility of any tool, model, or system: if the user groups will not use it…it is essentially (and in the true meaning of the term)…useless.

6.4.2 Prototype Development as a Case Study

The physical output of the model development is the working prototype and the GUI. The methodology in regards to conceptual positioning of the decision making process, and the development of the framework and the associated calculations and weightings, have been identified as critical foundation requirements to developing the GUI. In developing the prototype, a case study has been utilised to provide narrative and context to the 'working prototype', and to bring the models development forward from the conceptual phase into reality. This approach also allows the research to integrate elements of the discussion phase throughout the development phase. Therefore, each step of the prototype is discussed, following the format of the GUI sequencing itself. It will be observed, that using the case study approach is intended to give 'life' to the developing model. Areas which have not been fully addressed within the conceptual and framework sections will be placed throughout the case study, most notably in identification, connectivity, and discussion, in the areas of 'non-financial' factors, and 'financial' factors.

6.4.3 The Case Study

From the outset, there are important caveats to be clarified regarding the application of the developing prototype in the context of a selected case study. Critical reflection and SMART planning of the research project, identified the requirement to engage with a suitable project which was positive in three main areas. These were:

1. Current: A contemporary project is vital to ensure that the prototype is being tested against current legislation, technological considerations, and context of the business case process within the current national economic context.

2. Accessible: There are two dimensions to the accessibility of the project. The first being the geographical placement in respect of the researcher. This is not a critical aspect, however, the proximity to the key stakeholders and project participants, and the extensive use of ad hoc discussion and interview techniques within the research methodology, demonstrated a clear advantage. This touches upon the second dimension of accessibility, which is the willingness and co-operation of the NHS Estates Management teams, and the PSCPs in engaging with the research. This willingness is measured from a personal involvement perspective, and also the willingness to share project data and information in the development of the case study.
3. Satisfactory in Scope: Again, this is multi faceted, although primarily, the project must be of a reasonable size and value to justify application of a decision support process. Similarly, the size and value must be sufficiently acceptable to involve all standard aspects of the capital investment business case process, built upon the data and information collected and stored throughout the NHS own estate management and property appraisal processes.

The selected project that satisfied all of the above over-arching criteria, was the *Aberdeen Royal Infirmary (ARI) Reconfiguration and Backlog Maintenance* project. Reference may be made to the more strategic, or higher level, stages of the ARI Project, with revisiting the processes described earlier, in Figures 6.3.2a, and 6.3.2b, respectively, which show the broad connections and relationships between the backlog maintenance requirements, the refurbishment process, and the development and integration within the standard business case process. The case study as presented here, picks up at the integration points clearly shown in Figure 5.3.2b, by the gap bisecting line. The Estate Manager system has identified the priority areas for refurbishment and backlog maintenance works. What is also shown, is the placement of the line in the Initial Agreement (IA) phase of the business case. It is from this point that the case study begins.

6.4.4 The Prototype and Graphical User Interface

As discussed, the prototype and the GUI will be presented within the context of a case study. This section is therefore, designed to describe the mechanics of the model, the methodology behind the design and inclusion of certain features and, where relevant, the limitations of the prototype. To retain a systematic and logical approach to the section, the prototype is described against the case study in the same sequence as that which is designed into the GUI. It has been stated previously, that MS Excel® has been used as the platform, and as such the prototype is essentially a series of core worksheets. All worksheets are macros protected, and some of them are designed to be replicated as blank templates within the prototype, to allow for consecutive elements and sub-elements to be considered. In total then, excluding the cover page, there are seven core worksheets. These are described in greater detail below, although in summary are:

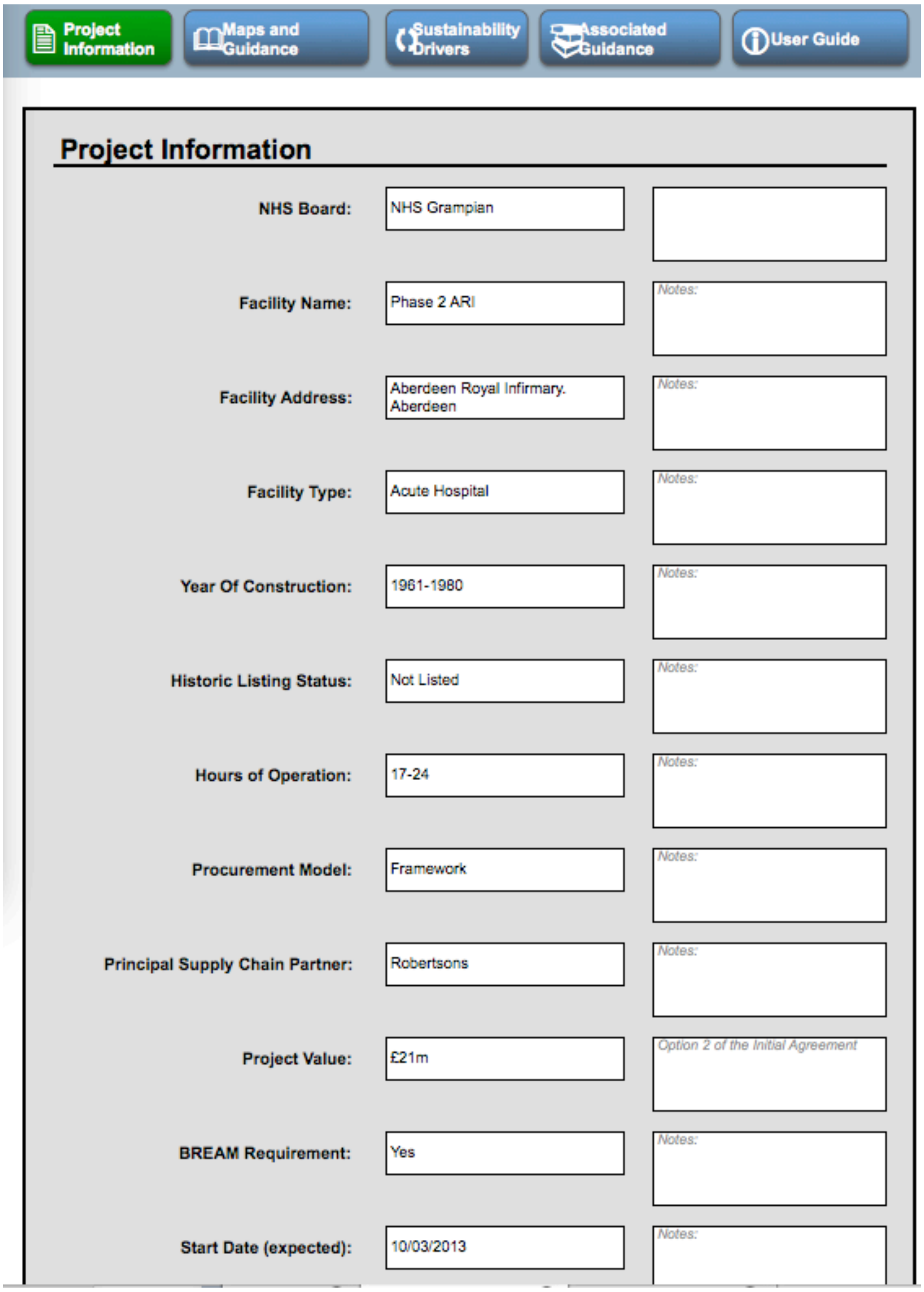
1. Project Information
2. Maps and Guidance
3. Sustainability Drivers
4. Associated Guidance
5. Criteria Selection
6. Options Selection
7. Decision Support Model

Worksheets 3 and 4 (Maps and Guidance, and Sustainability Drivers) are both placed as aide-memoire aspects of the model. The decision making process is a complex interaction of activities, and the property appraisal process is not visually supported in simplistic terms by the NHS guidance. Likewise, the range of sustainability drivers and factors to consider are vast. These worksheets therefore, afford the user some focused direction on overall movement of the process. This is an important point, as it is crucial that the decision makers do not lose context of the wider strategic aims and objectives.

6.4.5 Project Information

The project information page is designed to capture all of the 'necessary' information to create the base information requirements for the decision making process. This supports a fundamental MCDM requirement much discussed previously, in the identification of goals and objectives. The information required to do this, must have context, and it is this context which is sought and provided with the project information section. There are two key parts to this section. The first being the actual asset information, and the second, the opportunity of identifying and recording, the elements and sub-elements requiring consideration as a result of the higher level scope of works.

The asset information section is a single entry worksheet (in the sense that it is not replicable throughout any single prototype use or decision making process) The selection of asset information follows NHS Scotlands own guidance (NHS Scotland. Estates Asset Management. Property Appraisal Manual. pp.21-27. 2011) in identifying the baseline asset information required for context (Figure 6.4.5) It can be seen also, that although many of the information boxes are on pre-sets (by use of drop down menus etc.), there are 'open' boxes, which allow for project specific information (such as Contractors name, project value etc.). A filtering process was undertaken to exclude any information within the NHS standard format, which was deemed to be of little or no value to the exercise of refurbishment in a site-specific facility.



Project Information | Maps and Guidance | Sustainability Drivers | Associated Guidance | User Guide

Project Information

NHS Board:	NHS Grampian	
Facility Name:	Phase 2 ARI	Notes:
Facility Address:	Aberdeen Royal Infirmary. Aberdeen	Notes:
Facility Type:	Acute Hospital	Notes:
Year Of Construction:	1961-1980	Notes:
Historic Listing Status:	Not Listed	Notes:
Hours of Operation:	17-24	Notes:
Procurement Model:	Framework	Notes:
Principal Supply Chain Partner:	Robertsons	Notes:
Project Value:	£21m	Option 2 of the Initial Agreement
BREAM Requirement:	Yes	Notes:
Start Date (expected):	10/03/2013	Notes:

Figure 6.4.5. Asset specific information

6.4.5.1 Scope of Works

Understandably, a critical component of the decision making process, the scope of works provides the case study with the sequencing and direction of the identified maintenance backlog items or areas priorities for refurbishment. This is evidenced within the *NHS Grampian Property and Asset Management Plan* (PAMS pp.34) 2012-2021 (NHS Grampian 2012) which identifies the need to allocate the necessary funding to address high priority backlog items. In the context of the case study, this is the Phase 2 Building'. It is significant to note also, the identified 'next steps' discussed within the ARI Inpatient Reconfiguration Report (NHS Grampian pp. 25. 2012) which discusses the challenges and constraints placed on the planned infrastructure works, especially in terms of continued functionality of the asset. This is an early flag for identifying criteria later in the decision making process. The scope of works in this instance, is presented within the projects Initial Agreement document, (NHS Grampian. IA, Appendix A); this residing in the first phase of the overall business case process, and an extract to illustrate this is shown in Figure 6.4.5.1.

Initial Agreement for Phase 2 and East End 2

Scope of Works - Phase 2 Block

Element	Sub-Element	Do Minimum Backlog	Prioritised Backlog	Full Backlog
Structure	Roofs	Re-felt main flat roof	Re-felt main flat roof	Re-felt main flat roof
	External Facade	Balcony supports	Balcony supports	Balcony supports & replace external louvers
External	Windows	Window / blind repairs	Partial window replacement & repair	Replace all external windows floors 1-5 with double glazing
Internal	Walls	Upgrade of compartments to comply with Firecode	Upgrade of compartments to comply with Firecode	Removal / rebuilding of walls to suit changes in layout
	Doors, internal	No door replacement or repair	Door repairs only	Upgrade internal doors, including automatic doors
Fabric	Decoration	Part redecoration	Full redecoration	Full redecoration & some re-plastering etc
	Ceilings	Minimal replacement	Partial replacement	Almost full replacement
	Floors	Replace all poor condition flooring	Partial replacement of floor coverings	Replace all floor coverings
	Ward Kitchens	Upgrade of equipment	Upgrade of equipment	Upgrade of equipment
	Nurse stations	Upgrade all remaining wards to Static of Wandsworth Nurse Call	Upgrade all remaining wards to Static of Wandsworth Nurse Call	Upgrade all remaining wards to Static of Wandsworth Nurse Call
Internal Fixtures & Fittings	Sanitary Ware	Partial replacement of showers, baths, toilets	Partial replacement of showers, baths, toilets	Replacement of showers, baths, toilets
M&E Installations	Water Systems	Replace pumps, asbestos lagging & legionella works	Hot & cold water system replacement	Complete system replacement including tanks, pumps etc
	Space Heating	Asbestos lagging only	Full system replacement plus replace asbestos lagging to	Full system replacement plus replace asbestos lagging to

Figure 6.4.5.1. Scope of Works (extract)

What is also shown in Figure 6.4.5.1 is that the activity to '*Re-felt main flat roof'* has been highlighted. This signifies the selected 'demonstration' element and activity identified for use throughout the prototype development and testing. It should be noticed that the 'Prioritised Backlog' column has been selected, and this follows the higher level decision making process before tis intervention point, from the initial 'long list' of options, to the 'short list' (Figure 6,4.5.1). It was discussed with the NHS Estates Management, and PSCP team undertaking the Phase 2 project, that only main, or high value elements and components, would be considered for use with the model (at least initially), due to uncertainty of time and resource requirements outside of the current decision making and management activities. It was agreed, that the first element within the scope of works addressed this. It should be noted also, that the GUI provides a link button to access the scope of works, which is stored, by the decision maker/prototype user within the master file of the prototype.

6.4.5.2 Facility Elements and Sub-Elements

The second dimension to the Project Information section is the listing, and capability, of selecting the work activity required from the scope of works. Similarly to the asset data previously described, NHS Scotlands own Property Appraisal Guidance (2011 pp. 5-19) has been used as the template for design. This re-emphasizes the desire, and the requirement, of the prototype to be integrated within current systems. Therefore, the use of the same ordering, and coding identifiers validates the decision to do this. Figure 6.4.5.2 illustrates an extract of the complete list, but notably, the selected activity for the case study is shown as selected through usage of the pre-set drop down menus.

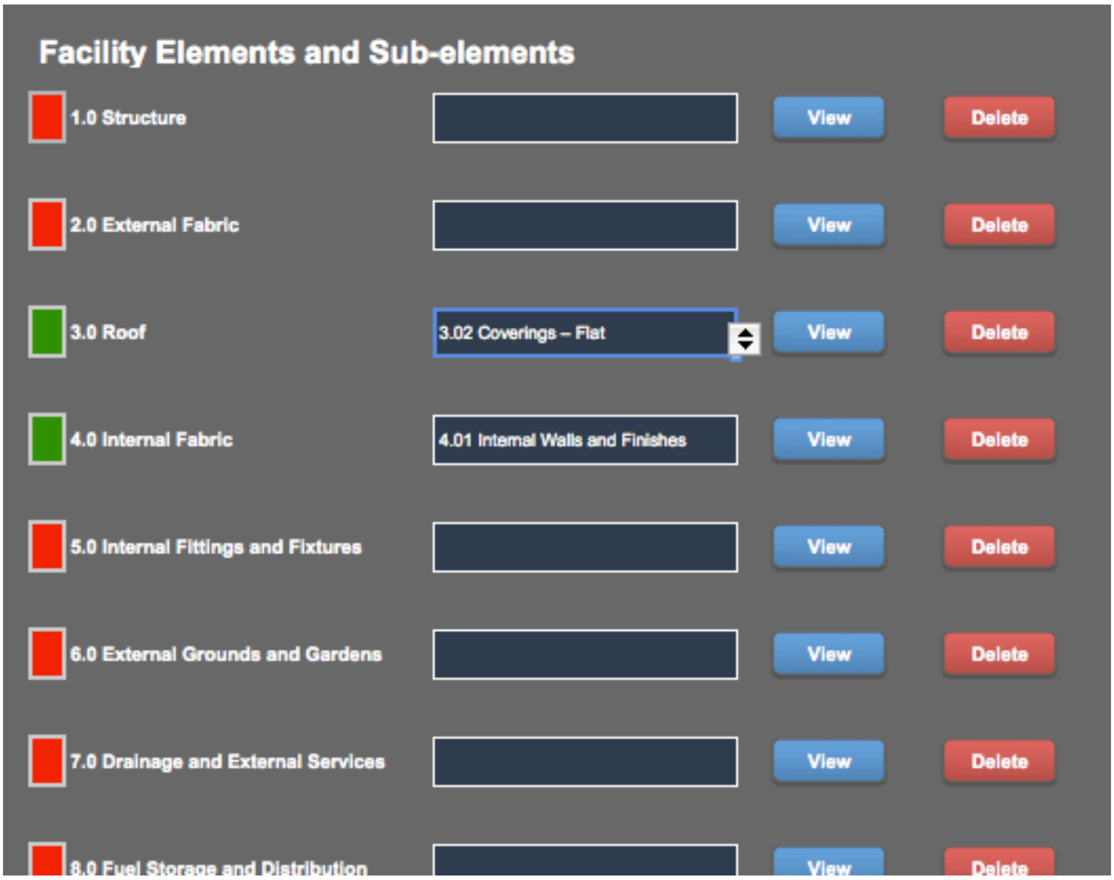


Figure 6.4.5.2 Elements and Sub-elements selection options (extract)

As with the link described on the GUI to access the Scope of Works, there is another link button, which accesses the BREEAM Pre-Assessment (if this is available) The BREEAM assessment is potentially a key criterion consideration, and in the context of refurbishment is very prescriptive in regards to the inclusion of specific elements. Likewise, there are connectivity's to the BREEAM credits themselves, in areas such as (but not restricted to) material selection, insulation selection, pollution issues etc. Given that a key objective of the over-arching model is to facilitate the decision making process to reduce variations (and thus, pursue Value for Money), the position of this function is proposed as valid.

6.4.6 Associated Guidance

One of the main characteristics of the model is its implementation and utility as a simple facilitation process. Key to this, is user-access to the necessary and relevant documentation and guidance. Section 4 provides this function as shown in the extract in Figure 6.4.6.

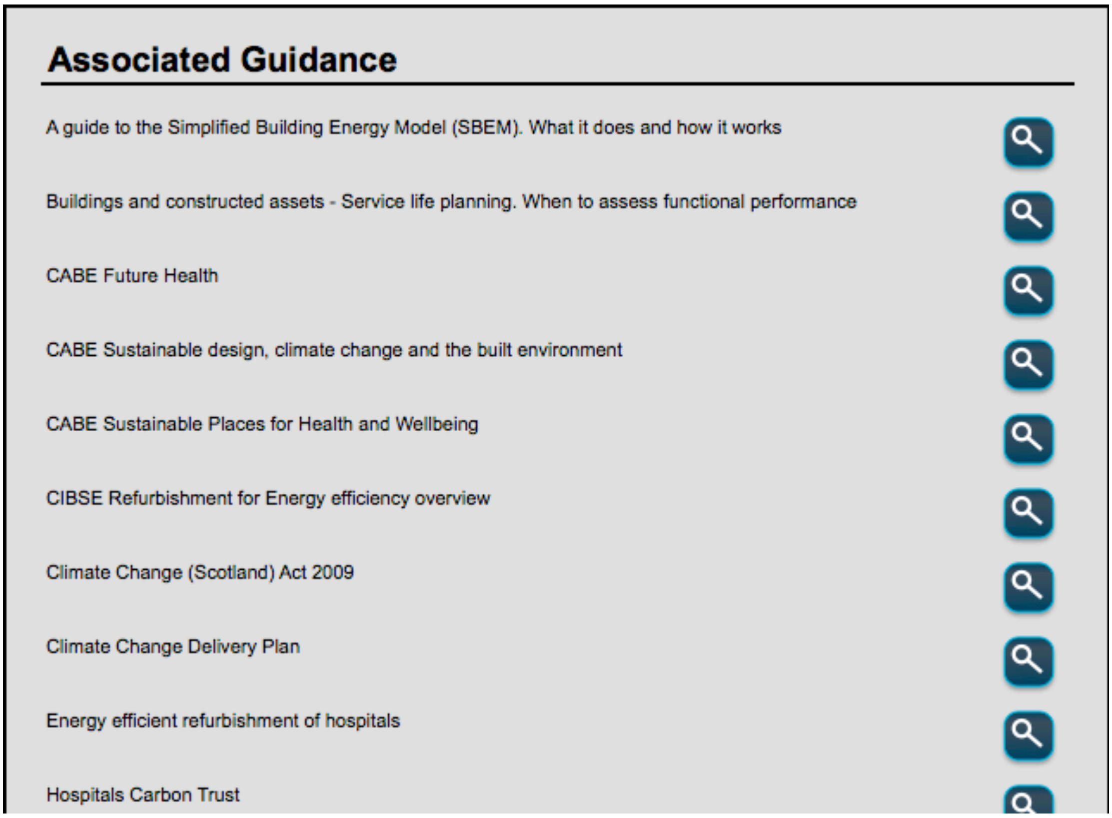


Figure 6.4.6 Associated Guidance (extract)

The sheer volume of information, guidance, and legislative texts associated (and required) when considering the multi-faceted aspects of hospital refurbishment activities, within the context of a sustainable approach is viewed by many, as being intimidating, and in some instances, a barrier to fluid consensus. This is supported through the primary and secondary data collection exercises. An important identified objective of the model therefore, was to provide a filtered, and coded access portal to the main documentation which the decision making team could easily access and review. From the secondary data exercise, a selected list has been placed in this section of the model. The coding system is simple alphabetical ordering, as this will allow all levels of users to locate the desired information by simple name searching. The list is not exhaustive, and has the flexibility for additions and subtractions to be made, however, for the purposes of the case study and the model development description, it is deemed adequate.

6.4.7 Criteria Selection

The development of the criteria selection page on the prototype, follows the processes discussed previously within the conceptual and framework development sections of the chapter. The same 'filtering' process has been undertaken, to explore and identify criteria from a high level consideration, down to a streamlined set of criteria which are entirely project specific. Critical reflection and a thorough review of the main legislative and guidance documentation was critical. The 'Initial Criteria' presented in Phase 1 are, in this context, based on the generic NHS related guidance, as can be seen in the extract inserted in Figure 6.4.7a.

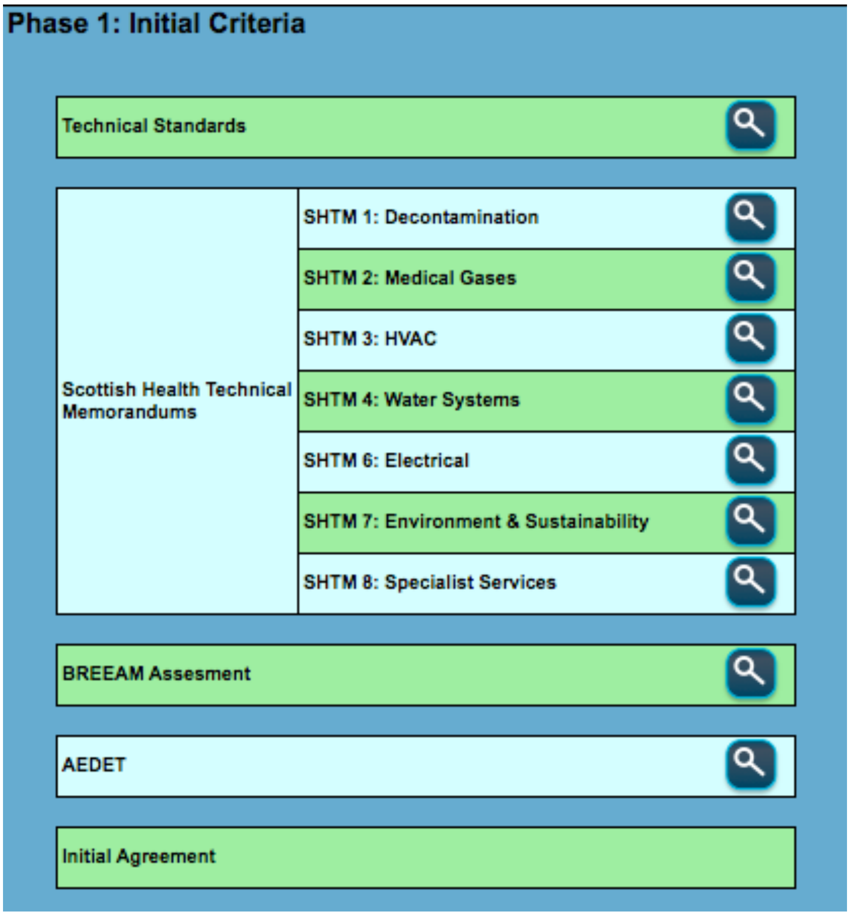


Figure 6.4.7a. Phase 1/Initial Criteria

The link buttons displayed are non-project specific at this stage, and take the user to the document stated. As can be seen from the attached case study CD Rom, the selected element *Flat Roof Coverings* is identified and labeled throughout the relevant documents prior (ideally) to the decision making workshop. The BREEAM assessment at this stage, is the BREEAM manual only, as at this stage of the project, it is most likely that only a pre-assessment will be complete (this link being available on the Project Information page). The final document (Initial Agreement) is an aide memoire, and also the first link to considering the project upon its own unique merits, which has been shown throughout the literature review, as a key challenge in assessing and measuring the refurbishment process (as opposed to the potentially blank canvas approach of a new build)

The following phase (and again, mirroring the previous conceptual and framework design) is consideration of the potential criteria (Figure 6.4.7b)

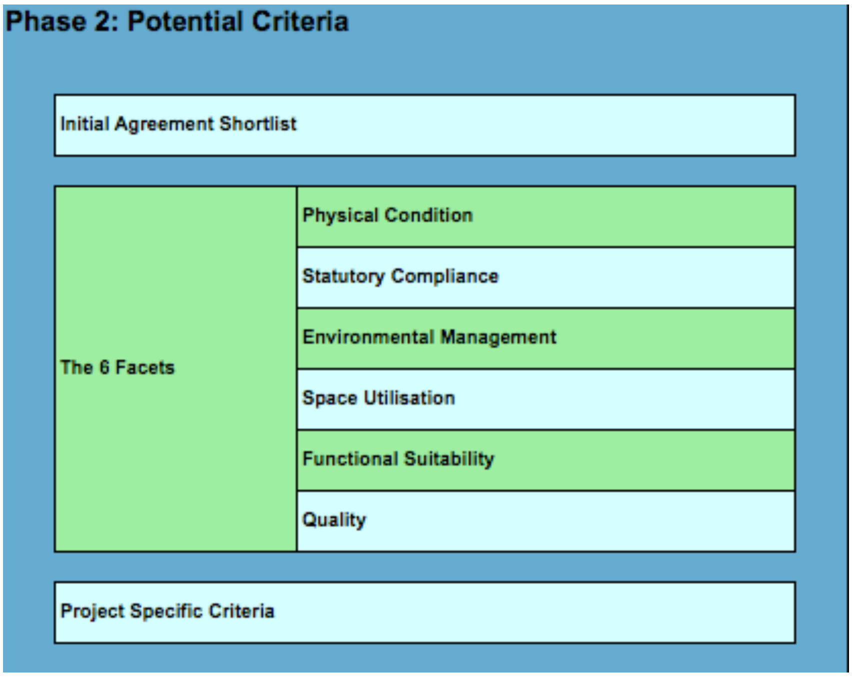


Figure 6.4.7b. Phase 2/Potential Criteria

The transition step from phase 1 to phase 2 is important, and as can be seen from both Figures 6.4.7a & b, the Initial Agreement document is the crossover document. This recognises the decision makers need to progress from the IAs standard 'long list' of options (as defined in the Scope of Works), to the shortlist which, for the case study are numbered at three (Figure 6.4.5.1) Next, the model guides the decision maker to consider the potential criteria in respect of the six facets (Figure 6.4.7b). No document links are provided within the GUI, as the goal is to encourage and facilitate the decision makers to review the project requirements in terms of the results and data input to the Estate Manager system. This touches upon the discussion concerning the actual 'gap' in the current knowledge and processes, in that the facets are identified and risk assessed (using the NHS own priority coding system), however, following this ‘identification’ process, the current systems stop short of providing a mechanism to explore and test the best fit options dependent upon the specific project variables. The final heading ‘Project Specific Criteria’, is again, a non-linked aide memoire device. It is envisaged that much of the project specific criteria will be identified and discussed in the previous steps, however, there may be idiosyncrasies which have been missed in terms of the form, function, orientation, or regional facility user groups, which have been missed throughout the more generic considerations, and as discussed above, may be unique to the challenges faced from a refurbishment project versus a new build.

The final criteria set, which is the objective of Phase 3, differs from the conceptual and the framework sections. Whereas the conceptual model shows a distinct set of criteria ‘for the criteria’…this step has been considered as superfluous to the actual objectives of identifying the final set of criteria. Instead, this phase has been modified to provide the ‘actual’ final criteria set (Figure 6.4.7c)

Phase 3: Final Criteria	
A	Thermal Performance - Warm Roof Required - U Values (W/m2K) = 0.25 (notional building)
B	Environmental Performance (HTM 07-07 pp.52) SuDS, Green Roof, Permeable surfaces etc
C	BREEAM Requirement
D	AEDET Requirement
E	Maintenance Availability
F	Guaranteed Source of Materials & Contractor
G	Minimal Disruption to services throughout Works Programme

Figure 6.4.7c. Phase 3/Final Criteria

The final criteria shown in Figure 6.4.7c are relevant to the case study, and have been identified and selected using the processes and methodology described throughout the chapter section.

The three phases described may be considered as the working components of the model/prototype, however, the criteria selection page on the GUI has additional support features. An extensive list of suggested 'Criteria Guidance' has been added, to allow the decision makers to review the sections and consider whether any criteria, which may not have been identified throughout the filtering process described above, have been missed or overlooked. The list, taken from Kirk and Dell'Isola (1995 pp.103) is therefore intended to stimulate further discussion and allow for experience and subjectivity to be included within the discussions.

The final additional component on the criteria selection page, is a more detailed and inclusive list of a wide range of relevant standards and publications which may not have been identified as being core publications for inclusion with the previously discussed 'Associated Guidance' section of the GUI.

6.4.8 Options Selection

As with the development of the criteria selection page on the GUI, the options selection follows the processes described throughout the conceptual phase. A filtering process is employed to streamline the higher level considerations into a clearly discernible, measured, and logical range of potential options, specific to the element, sub-element, or component under consideration, relevant to the current focus of the decision support/making process. The first phase of this process being the identification of the 'Initial Options' (Figure 6.4.8a)

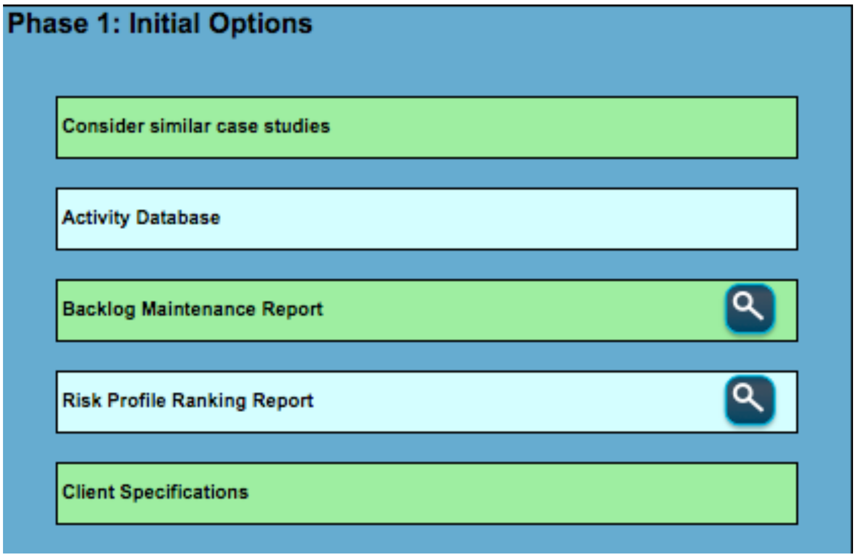


Figure 6.4.8a. Phase 1/Initial Options

The initial options section of the GUI presents a mix of both linked document buttons, and also aide-memoire headings. It is highlighted, that the process begins with a search process of similar case studies. The project specific *Backlog Maintenance Report*, and the *Risk Profile Ranking Report*, are then available, specific to the project in question, and resultant from the activities undertaken throughout the property appraisal process (linked again, to the Estate Manager tool) This is the higher level identification of specific element or component characteristics. It is noted at this point (and this is applicable to the whole decision making process and GUI interaction throughout), that although the process and the GUI sequencing, is presented as a linear process; this is by no means a strict requirement of the methodology. Throughout, the decision making team and/or, the workshop facilitator must record the connections between different aspects of the process as it progresses. An example of this, would be the noting of 'early flags' from the progressive phases, for consideration further along the decision making process. BREEAM requirements via the pre-assessment are a good example of this, as are cost considerations of any options, which may be sourced through case studies etc.

The second phase narrows the options selection process still further, and considers the 'Potential Options'. It is reiterated, that this process is considered against Kishk et al (2004) adapted filtering process. Phase 2 introduces detailed data and information requirements, both from web-based data sources, such as the Building Cost Information Service, and the Green Guide to Specification, and integrates these with the NHS own guidance in respect of life expectancies of elements/components, and typical rates to be considered as a 'rule of thumb' guidance approach. Proprietary literature, links all of the preceding steps, from case study, to cost considerations, and by this point, the decision making team, or facilitator, is developing a short list of functionally suitable, and financially feasible option choices. Figure 6.4.8b shows the layout of phase 2.

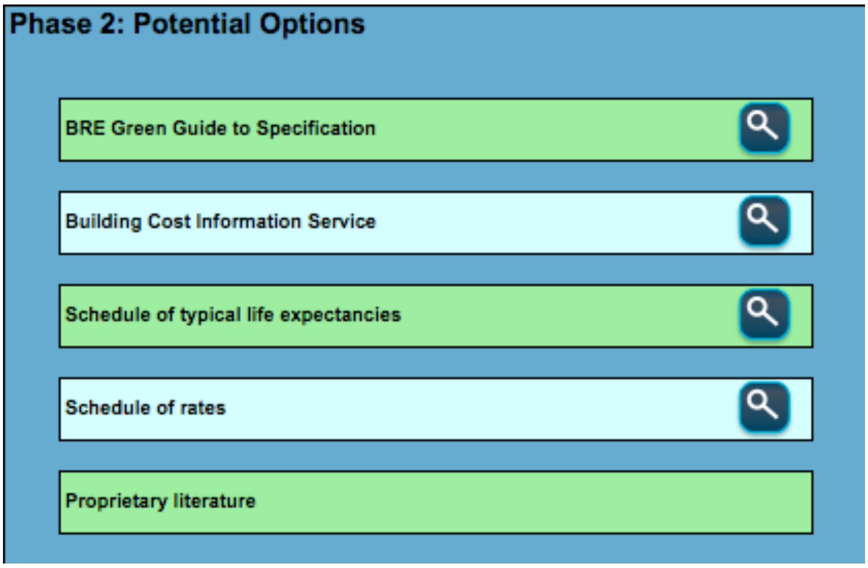


Figure 6.4.8b. Phase 2/potential Options

Phase 3 is a final 'check' for the decision making team, and as with previous sections, is designed as an aide memoire facilitation list to encourage discussion (Figure 6.4.8c)

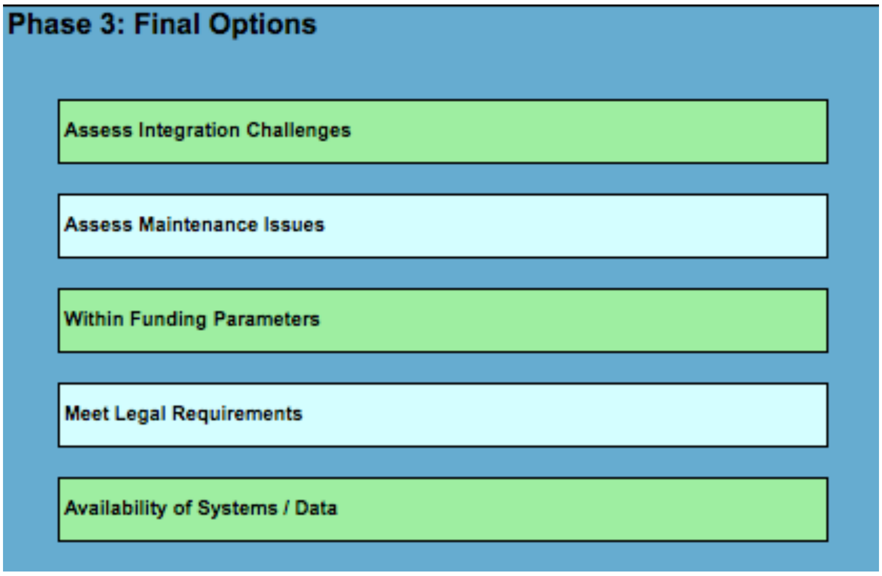


Figure 6.4.8c. Phase 3/Final Options

By the end of Phase 3 of the Options Selection phase, the decision making team should have identified a discrete and logical range of potential options. The case study has identified these simply as Options A, through E, offering a set of five competing options to satisfy the requirements set out in the initial Scope of Works. Figure 6.4.8d illustrates how these appear on the GUI.

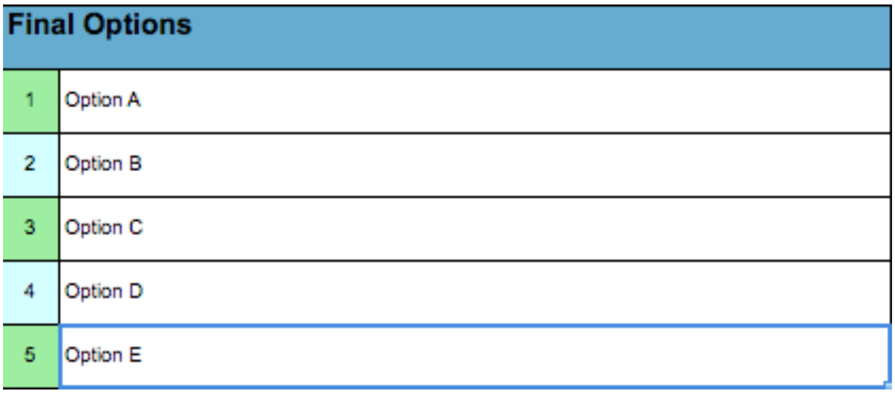


Figure 6.4.8d. Final Options Selection box

Replicating the design of the criteria selection page, the processes and phases described above, are the actual dynamic working components of the model itself. Additionally to this however, the GUI offers further guidance and flexibility in the facilitation process, by means of a *Key Suppliers by Product Group* section. This section is sourced from the 2010 Final Report entitled *Characterising the Market for Refurbishment Works in the Built Environment* (AMA Research. 2010) The objective of the additional guidance and the reports findings, are to sign-post the decision making team towards accredited and certified suppliers and manufacturers of the main element and component product groups throughout the UK. As discussed previously, the decision making process is intended to be iterative in nature, and as such, each end of the options selection spectrum (*consideration of similar case studies* to *availability of systems data*) is potentially enhanced and improved by offering a starting point from a credible data source.

6.4.9 Decision Making

It has been shown that the identification of both Criteria and Options (as set out in the GUI) has followed the conceptual five step MCDM design process shown in Figure 6.2.3. Entering the decision making phase of the prototype is no different in this respect. However, steps 4 and 5 (Alternatives or Options evaluation against the identified Criteria, and Make Decision step, respectively) are the actual heart of the dynamic decision making mechanism, and these are combined into the 'Decision Support Model' page on the prototype. To reiterate the design of the combined steps (4 and 5), reference is made back to Figure 6.3.1a in the framework development section. The fundamental design of the weighted evaluation process, together with the calculations and formula describing this, are exactly the same, although transposed and hidden within the GUI itself. The identification and inclusion of both final Criterion sets, and options lists has already been discussed, therefore the section proceeds from the Criteria/Options evaluation Step, through to the identification of a preferred option (Step 5) What is discussed, is the actual mechanism in action in the context of the case study, to support and reinforce the earlier description of the mathematical processes.

6.4.9.1 The Criterion Function

Following the calculation and comparison processes discussed by Kirk and Dell'Isola (1995 pp. 102-103) the double process of criteria and options evaluation begins with the comparison and ranking of each identified criterion, against all other included criteria. Figure 6.4.9.1 demonstrates how this is expressed in matrix form in the prototypes GUI.

A	Thermal Performance - Warm Roof Required - U Values (W/m2K) = 0.25 (notional building)	A						
B	Environmental Performance (HTM 07-07 pp.52) SuDS, Green Roof, Permeable surfaces etc	A3	B					
C	BREEAM Requirement	AC1	B2	C				
D	AEDET Requirement	A4	B3	C3	D			
E	Maintenance Availability	AE1	BE1	CE1	E4	E		
F	Guaranteed Source of Materials & Contractor	F2	F2	F2	F4	EF1	F	
G	Minimal Disruption to services throughout Works Programme	A4	B4	C4	G3	E4	F4	G
		9	7	6	1	8	10	2

Figure 6.4.9.1. The Criteria evaluation matrix (showing weightings)

What Figure 6.4.9.1 shows, is that the modeling process has identified seven individual criterion (non-financial), which have been taken forward (automatically within the prototype) from the filtering and selection process described and illustrated in section 6.4.7. The cells on the right hand side of the matrix now allow for the process of comparison to be undertaken, using the following ranking, or 'importance' scale.

4 – Major Preference
3 – Medium Preference
2 – Minor Preference
1 – No Preference

In the example illustrated above for example; Criterion A (Thermal Performance), measured against Criterion D (AEDET Requirement) is considered by the decision maker to be 'A4', or, the decision maker has identified a major preference for criterion A over Criterion D. In the example of Criterion A (Thermal Performance) considered against Criterion E (Maintenance Availability), the level of importance by the decision maker has been assessed as being even, or of no preference. Therefore, a cell entry of AE1 is recorded, as shown.

The prototype is pre-set to offer and restrict the decision maker to a choice of the scale rankings shown above, by means of drop down menus for each cell, which allow all possible decision choices *relative to the criterion being compared.* It should be highlighted at this point, that the total 'possible' number of criterion available to the decision maker has been limited to a maximum of ten, with a minimum input of two. The rationale for the maximum limitation, is that (as described throughout the chapter), the MCDM technique employed is 'discrete' as opposed to 'continuous', and therefore deliberately designed within easily workable limitations.

Referring again, back to a previous section, Figure 6.3.1b illustrates the calculation for applying a 'Raw Score' and criterion 'Weighting' to allow for a process of normalisation to the comparison results. Within the prototype, these calculations have been hidden and automated by means of the Excel formula function, however as Figure 6.4.9.1 illustrates, the resultant weightings (between 1 and 10) are still shown on the model.

6.4.9.2 The Options Matrix

The process undertaken within the Options Matrix is also referenced back to section 6.3.1 'Designing the Framework'. As with the 'Final Criteria' allowance, the prototype has again placed parameters on the number of potential allowable options to be included. A corresponding number of ten maximum and two minimum has been programmed in to the GUI, following a discrete MCDM path. The options selection matrix is actually comprised of two main dimensions; these being the non-financial, and the financial. These results are ultimately identified within the GUI as:

1. Non-Financial Preference Ranking
2. Benefit to Cost Preference Ranking

Figure 6.4.9.2a illustrates a matrix extract showing the non-financial evaluation of the Final Options.

		9	7	6	1	8	10	2	Total Score
1	Option A	4	4	3	2	1	2	5	122
2	Option B	5	3	2	2	4	2	5	142
3	Option C	4	3	2	2	3	3	5	135
4	Option D	5	4	3	2	4	4	5	175
5	Option E	4	4	3	2	2	3	5	140

Figure 6.4.9.2a. Options matrix

It should be noted that the top range of cells shown in Figure 6.4.9.2a, are the resultant criteria weightings shown in the bottom range of cells in Figure 6.4.9.1. The significance and importance of these will be described.

Figure 6.3.1a in section 6.3.1 'Designing the Framework' shows each option cell within the matrix as a split cell. This has been hidden within the prototype using the formula functions of Excel. Similar to the importance scale used for criterion comparison, the selected options are also subject to a process of ranking by use of a 'Performance Scale'.

The performance scale in the context of the prototype design (and illustrated within the case study) is based on non-financial calculations at this stage. Each option is assessed by the decision maker in the context of its performance when compared against each individual criterion. The following scale is used:

5 – Excellent
4 – Very Good
3 – Good
2 – Fair
1 – Poor

This is a significant point in overall decision-making process, as the ranking of each option in terms of performance, may be carried out in both subjective and objective terms. The subjective input capturing the experience and heuristic input from the decision maker, or decision-making team, and the objective through more quantitative terms such as capacity, size, quality of materials etc. The main significance being, that this stage is key to the transition and integration of the decision making process from a subjective and qualitative activity, to that of an objective, and measured activity. This reflects one of the key drivers for the research overall, in seeking to develop a formalised process of specification and design selection, which is absent within the current business case process.

Referring again to Figure 6.3.1a, the completed performance scale results from each option, are multiplied by the raw score of the corresponding criterion, and the summed results within each cell are added to produce a finalised total. The highest total score is thus ranked as the highest ranked option (in non-financial terms) In Figure 6.4.9.2a, this is shown as Option 'D', with a highest total score value of 175.

The Prototype has also been designed with the facility to progress the non-financial ranking results (described above), and to present them in terms of financial preference. Figure 6.4.9.2b illustrates the matrix extract, which carries out the financial ranking process.

Total Score	Cost	BTC Ratio
122	£140,000	0.87
142	£154,000	0.92
135	£146,000	0.92
175	£175,000	1
140	£151,000	0.93

Figure 6.4.9.2b. Financial ranking process

What Figure 6.4.9.2b shows is the use of Benefit to Cost (BTC) Ratio calculations to provide a financial preference ranking to the non-financial results derived previously. A simple calculation is undertaken which divides the total non-financial score, by the cost (or projected cost) of the element or works from which each identified final option comprises. So for example, the case study demonstrates in Figure 6.4.9.2b, that 175 is the highest value (ranking) total non-financial score. The costs of this option are calculated as being £175,000. This figure may be inserted to the model as element and components 'only', or as inclusive of all contractors fees etc. The only rule being, that the same convention is undertaken for all identified options costs. The calculation is therefore:

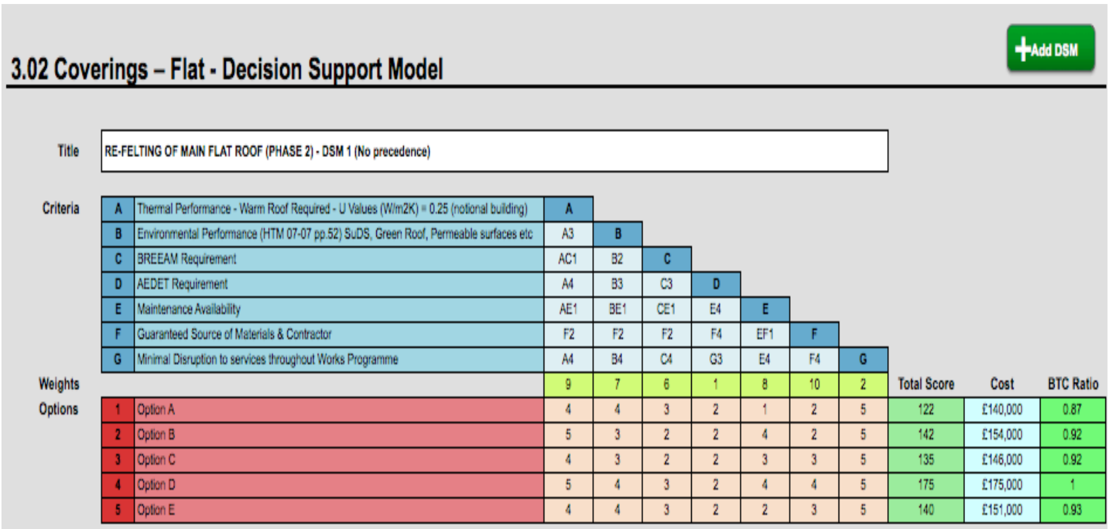
175/175000 = 0.001

The prototype cells have been pre-set to multiply each BTC value by ‘1000’ to negate the occurrence of extended decimal places. Therefore, the completed calculation for the BTC value is:

175/175000 = 0.001(x 1000) = 1

This calculation is carried out for each total non-financial ranking score against each option cost value. The option with the highest BTC value, is identified as being the highest ranked option in financial preference terms.

The complete decision making matrix (as designed on the GUI) encompassing the criterion evaluation, options scoring, and financial ranking is shown in Figure 6.4.9.2c.



3.02 Coverings – Flat - Decision Support Model

Add DSM

Title: RE-FELTING OF MAIN FLAT ROOF (PHASE 2) - DSM 1 (No precedence)

Criteria	A	Thermal Performance - Warm Roof Required - U Values (W/m2K) = 0.25 (notional building)	A									
	B	Environmental Performance (HTM 07-07 pp.52) SuDS, Green Roof, Permeable surfaces etc	A3	B								
	C	BREEAM Requirement	AC1	B2	C							
	D	AEDET Requirement	A4	B3	C3	D						
	E	Maintenance Availability	AE1	BE1	CE1	E4	E					
	F	Guaranteed Source of Materials & Contractor	F2	F2	F2	F4	EF1	F				
	G	Minimal Disruption to services throughout Works Programme	A4	B4	C4	G3	E4	F4	G			
Weights			9	7	6	1	8	10	2	Total Score	Cost	BTC Ratio
Options	1	Option A	4	4	3	2	1	2	5	122	£140,000	0.87
	2	Option B	5	3	2	2	4	2	5	142	£154,000	0.92
	3	Option C	4	3	2	2	3	3	5	135	£146,000	0.92
	4	Option D	5	4	3	2	4	4	5	175	£175,000	1
	5	Option E	4	4	3	2	2	3	5	140	£151,000	0.93

Figure 6.4.9.2c. Complete decision making matrix

Figure 6.4.9.2c shows the results obtained from undertaking a single decision making process. It shows that Option D, is the most preferential option in non-financial terms, and also by use of the BTC ratio calculation, it is the most preferential option in financial terms. Despite the fact that the modeled results shown in Figure 6.4.9.2c have been derived from a process of both subjective and objective input, the decision maker must seek to reinforce confidence that the variables included within the process could not produce a more informed, functional, or value for money oriented approach, if the model was re-run with changes to the variables and/or scenario. This ‘checking’ process, is defined as undertaking a process of sensitivity analysis (or testing). Ellingham and Fawcett (2006 pp.162) identify this as a full rounding process in evaluating a preferred option. They highlight the point that relatively small changes in the earlier assumptions of the options appraisal process have the capacity to cause significant changes to the end result by means of exponential change and re-routing of connectivity’s between variables. This is accepted within the model, and a process of sensitivity analysis has been designed into the GUI. Each Decision Support Model (DSM) or matrix is replicable within the decision-making section of the GUI. Although theoretically, there is no limit to the number of DSMs which can be replicated, it is unlikely that this will be carried out more than three or four times (given the restricted number of Criterion) It should be noted that it is only the Criteria which may be changed within the sensitivity analysis, in context of assigning precedence to any individually selected criterion, and that the sensitivity analysis changes are only applicable to the ranking results of the criteria importance scale (1 to 4). Any changes in the actual criteria or the options selected, will necessitate the construction of a fresh matrix and DSM page by use of the criteria/options final selections discussed previously. Figure 6.4.9.2d shows the DSM sensitivity analysis undertaken in the context of the case study.

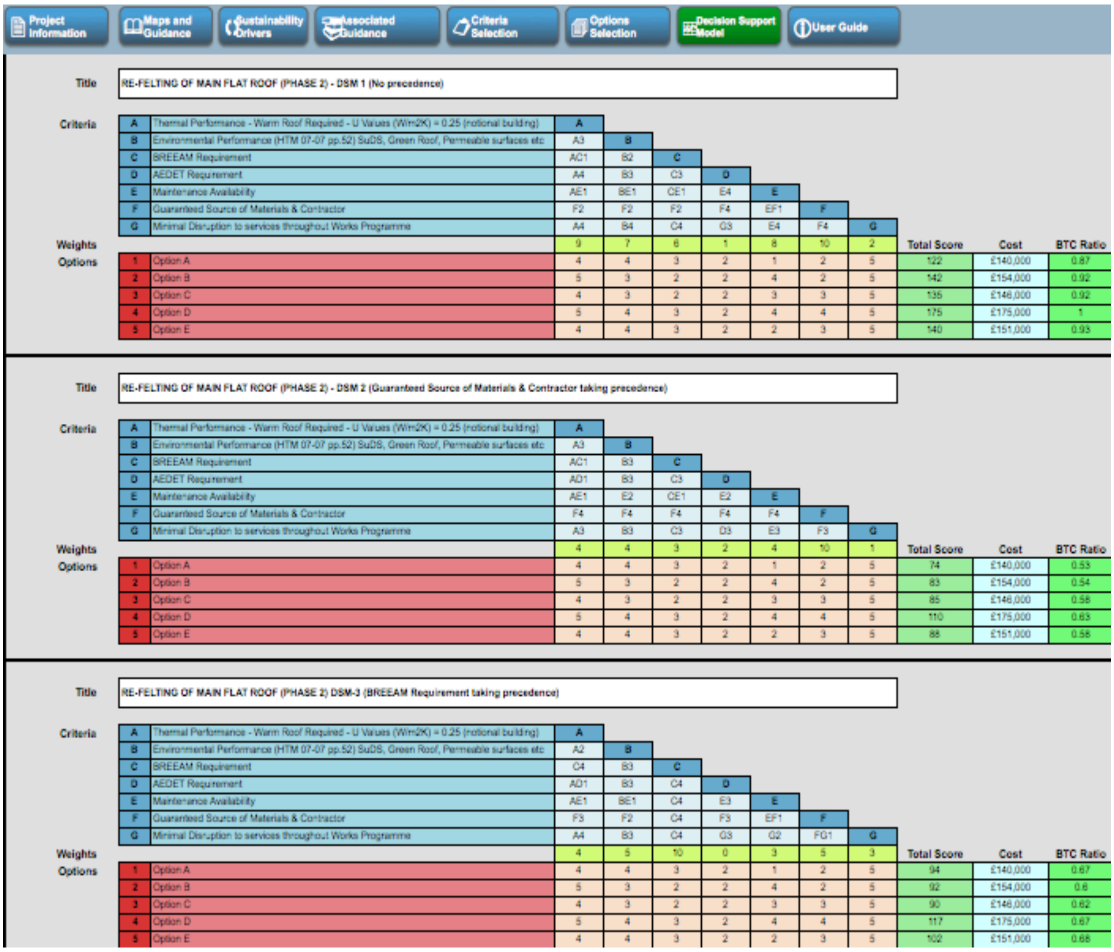


Figure 6.4.9.2d The DSM in Sensitivity Analysis

What is shown in Figure 6.4.9.2d is that DSM 2 has identified 'Guaranteed Source of Materials & Contractor' as taking precedence in the ranking and weighting of the final criteria. DSM 3 has identified 'BREEAM Requirement' as talking precedence. The subsequent results in both non-financial, and financial preference terms is clearly noticeable, although interestingly, Option D is still the preferred option in all three scenarios. It should be noted at this point, that although Option D is found to be the preferred option in all three scenarios, closer inspection of the options cost, shows that it is significantly more expensive than its competing options. This is a good indicator that value for money, as opposed to the cheapest option, has been considered as an inbuilt part of the process. Returning however, to earlier points made in the discussion, the results as they stand in Figure 6.4.9.2d, although correct and measured, are not presented in terms of clarity that is user friendly to the model user.

6.4.9.3 Presenting the Preferred Options within the GUI

In terms of the prototypes usability, and based upon the end result of creation and presentation of a project decision making report, it was considered critical to present the sensitivity tested results of the decision making process in a simple and user friendly format. The non-financial and the financial preferences have been kept separate for this process, mirroring the actual process undertaken in each DSM. Figures 6.4.9.3 a & b (respectively), show how these are presented within the GUI, in the context of the case study.

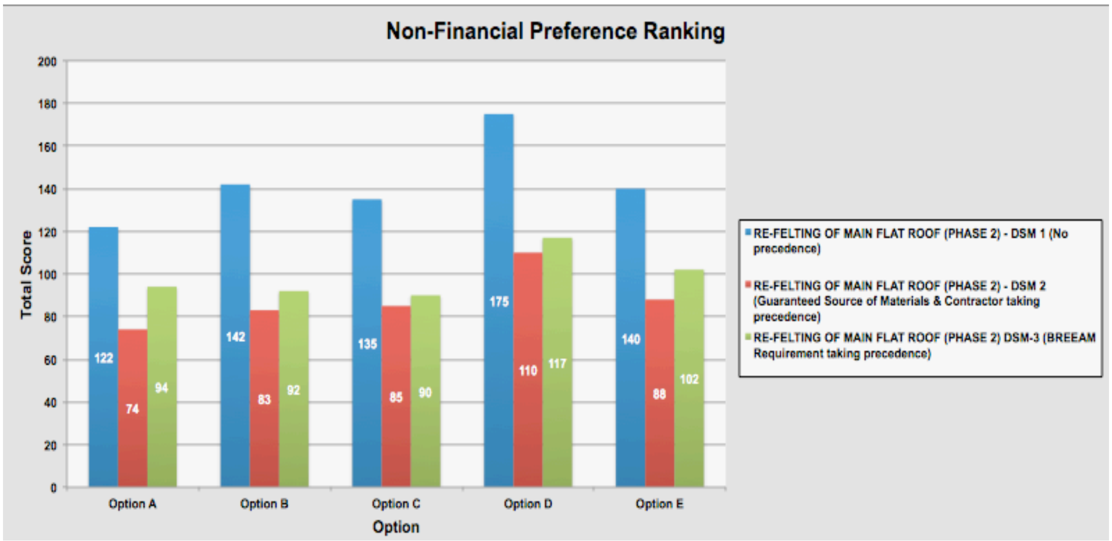


Figure 6.4.9.3a. Non-Financial Preference Ranking GUI display

Figure 6.4.9.3a shows that each DSM has been modeled showing the non-financial preference rankings for each final option choice. Use of clearly discernible colouring of the results columns allows for immediate appraisal to be undertaken of the sensitivity-tested results in comparison with one another. The results are worth closer scrutiny in demonstrating the changes to the results by the process of sensitivity analysis. Although Option D is still the preferential option in the case of all three DSM 'runs', the changes in criteria reference made to DSM 2 and 3 (Figure 6.4.9.2d) have noticeably closed the gap disparity between the total score weightings of each non-financial comparison, especially in options A through C.

A similar visual representation of the results is designed for viewing and comparing the financial dimension of the DSM (Figure 6.4.9.3b). Again, Option D from the case study is shown as being the preferred option, this time in financial terms. What is immediately noticeable regarding the comparisons of each DSM run, is that Option D is significantly higher in presence than its competitors (despite, as previously pointed out, being by far the cost high cost option) However, DSM 3 shows a slightly different set of results. Considering DSM 3 in Figure 6.4.9.3b (the green column), Option A is a financial 'tie', and Option E is actually more preferential (albeit slightly) than the otherwise dominant Option D.

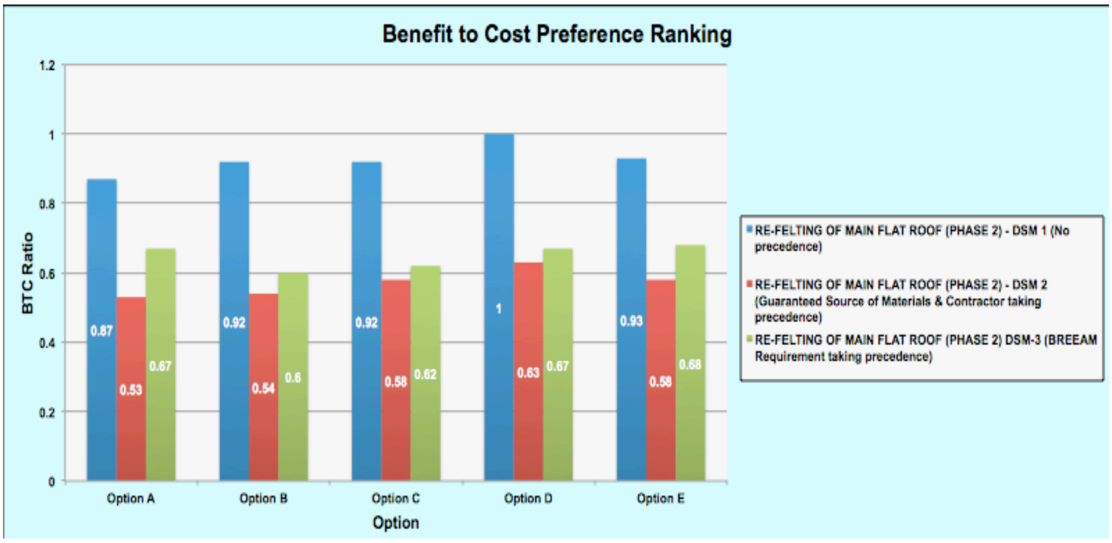


Figure 6.4.9.3b. Benefit to Cost Preference Ranking GUI display

This illustrates very clearly the 'knock on' effects of testing the variables and criteria in terms of precedence and/or importance, to the decision maker of unique (and perhaps changing) characteristics of the refurbishment project. In the case of DSM 3, the precedence was given to the BREEAM Requirement, although especially for the more complex and higher value elements and components possible as the options range, the example discussed reinforces the advice to the decision maker to undertake a process of sensitivity analysis with a range of realistic variable changes.

6.5 Limitations of the Prototype

It is reiterated from the outset, that the model development is prototype based. The prototype itself has been researched, designed, and constructed, within the time and resource parameters of a time horizoned research project. Therefore, there are aspects of prototype which have been designed with a view to further detailing in a potential post-doctorate setting. Similarly, the parameters of the prototype itself have been required to be set within design boundaries, meaning that although the methodology employed throughout the models design and user capability are sound; time, resource, and scope constraints, have demanded that a 'design limit' has been necessary. This is most clearly seen in the final phases of the GUI concerning the use of BTC ratios in offering a basic form of financial preference ranking. Although perfectly correct, the issue of financial preference, and especially in the triple dimensioned context of the sustainability model, would require an additional component or mechanism to consider and evaluate the Life-Cycle Cost calculations of each final and preferred option.

In the spirit of integration, the Life-Cycle Costing (LCC) component of the model would ideally linked through the Excel worksheets, to allow for the 'Cost' column on the DSM page (Figure 5.4.9.2b) to be the already evaluated preferential cost following a process of Discounted Cash-Flow and Net Present Value calculations. This process would also support the BREEAM requirement (if employed) on pursuing the LCC credits (BRE. 2008. Pp.60). In anticipation however, of possible expansion of the model in post-doctoral terms, as discussed above, the LCC link has been designed in to the GUI on the DSM page. In the context of the current prototype, this acts as an aide memoire, however an additional worksheet with LCC calculations is the ultimate desired amendment for this aspect of the prototype.

The prototype also relies mainly, on the use and linkage with stored PDF format files of the main legislative guidance and documentation, and as such, these are stored within protected files within the master DSM prototype file. Given that the guidance and legislation is constantly evolving, these documents should ideally be changed to web-based, and therefore source updated, hyperlinks. This would move the prototype/model, into the arena of a web-based system, as opposed to a stand-alone decision support model (as it is currently), however, the benefits of doing so seem clear.

Related to the above, the issue of prototype/model/system integration is also an area, which has capacity for development, and is currently restricted due to the resource and scope reasons described earlier. From an institutional design perspective, the integration possibilities are focused on the existing

NHS Estates Management systems referred to throughout the literature review and the thesis chapters. From a GUI specific viewpoint, there are links embedded within the current prototype, notably for the *Green Guide for Specification*, *Building Costs Information Service* (BCIS), and the *Activity Data Base* (ADB), which are recognised, although not actually accessible (aside from the Green Guide) due to licensing and user costs. Access to the ADB and the BCIS especially, would provide a closely targeted integration opportunity to interact with past and present case studies, factor in the latest regulatory or institutional requirements, and to benchmark expected cost parameters as the design develops. The implications for avoiding future variations and potential legal issues is clear, and although the decision support model discussed throughout the research does factor these issue into the main drivers and objectives for the models development, a key limitation is the restricted access to these systems and tools, and the required permissions to work with and develop the existing framework and software designs.

CHAPTER SEVEN TESTING & VALIDATION

7.0 Introduction

This chapter reports on the testing and validation phases of the completed model prototype. This was a critical phase of the prototypes development, and an iterative process was essential to allow feedback and improvements to be applied where identified. This is illustrated in Figure 4.2 in the methodology chapter. The mixed-methods approach incorporating both deductive and inductive methods, is clearly demonstrated, and this is also presented in the cyclical nature of the design development, again, this is illustrated in Figure 4.2

It was shown in the model development chapter, that a case study of a real-time project was used as the contextual basis for describing the models characteristics and working mechanism. This was built up from the conceptual phase, through the prototype development phase. It is critical however, for the prototype to be tested and validated by the intended user group of the model. This requires the prototype to be tested by panel (or industry) experts, as shown within the earlier research methods chapter. The main aim of this chapter is therefore, to expose all aspects of the model to the expert panel to identify three main areas of identified validation. These are:

1. Effectiveness of the model for intended use
2. Efficiency of the software platform and the user interface
3. User satisfaction

The testing of the prototype in regards to the above three main areas was therefore undertaken by presenting the case study example to selected experts and stakeholders, and working through the models worksheets and functions in a methodological manner. Once this process had been undertaken, the participants were given an open-ended opportunity to revisit and re-test any facets of the prototype design or function if they chose. Once this exercise was agreed as complete, the validation exercise then took place, with individual participants providing scored feedback, by use of Likert scales, which allowed for the results to be statistically modeled to analyse any variance between the findings of the expert panel.

7.1 A Pilot Study

Working on the same principles for the main data collection excercises discussed in detail in the methodology chapter, it was considered appropriate to conduct a pilot study of the testing and validation processes prior to the identification and invitation to industry experts. A key consideration in undertaking the pilot study, was to ensure that any issues in regards to format or continuity of the case study, were addressed (if required) prior to engaging professionals from a multi-disciplinary pool. In doing this, it was the intention that the scoring and feedback in the validation phase would be focused purely on the models functionality and efficacy, as opposed to being diluted by observations on aesthetics and/or format.

7.1.1 Selecting the Pilot Study Group

The pilot study group was selected form a mixed group of academics (related to construction and design), and experts with professional experience. A total of 9 participants were invited, from backgrounds including project management, engineering, quantity surveying, and architecture. It was identified, that there were no NHS management professionals within the pilot group, although given the requirements of the study, this was deemed acceptable. It was considered critical however, that the participants of the Pilot, were of a suitable technical and professional background and level of experience. The 'hybrid' *stratified purposeful* and the *criterion sampling* approach, discussed in detail in Chapter 4, demanded that the same rules and selection criteria apply, to allow for a robust and credible set of results. It was understood and accepted though, that in the case of the pilot study design for the testing and validation process, engagement with NHS professionals was not a necessity. This is justified by the aims of the pilot itself, which is to test the process and invite criticism on formatting and delivery, and also by the fact, that the access to NHS professionals matching the required entry criteria, was more difficult to obtain, and therefore was prioritised for invite into the main testing and validation exercise.

7.1.2 Results of the Pilot Study

The qualitative feedback from the pilot group was very informative in regards to the presentation and delivery of the case study. There were a very few minor comments regarding the model itself, and mostly were posing a rhetorical question of whom the end user might be in NHS terms. Given that within the main validation exercise, the identified end users from the NHS management teams would be participants, these queries were self-answered by the main testing and validation design.

In presentation terms, it was noted that the researcher as presenter, should concentrate of pitching the presentation at a consistent and steady speed. There are navigation buttons within the model, which the presenter ignored throughout the pilot, in favour of the worksheet tabs at the base of the GUI page. It was suggested that the buttons were used for ease of interpretation and viewing from the audience. A very useful point was offered in the 'order' of presentation. Whereas the prototype was presented in a linear fashion for the pilot, working from the first worksheet on the GUI, systematically through the final worksheet; it was suggested that the final decision making worksheet, which shows all of the sensitivity analysed results, and the graph visuals of the non-financial, and financial preferences, be shown to the audience earlier. The reasoning for this was that it was felt by the pilot group, that by an early observation and discussion on the end result, then context would be provided which would allow for greater understanding of the previous steps as they were discussed. This directly influenced an amendment to the presentation format for the main panel of experts.

Table 7.1.2 shows the results of the pilot study. These have been presented to show the Mean scores within the maximum and minimum boundaries of score parameters. The Standard Deviation has also been illustrated to provide an analysis of variance of the combined results. The overall results of the pilot were very positive in deriving an overall average scoring rate of

4.18, with a relatively small Standard Deviation average of 0.55. It was identified however, that the scoring rates were derived from a more academic perspective in regards to model design, and there were more neutral inputs in areas which sought to gauge functionality relating the business case and other specialised areas. It is noted, that no attempt was made to filter the results by professional discipline, as the objective of the pilot was not to ascertain the individual responses by discipline. This would be replicated within the main study, and will be discussed later in the chapter, with a more in-depth discussion encompassing limitations and recommendations.

Effectiveness for intended use	Mean	Max	Min	SD
Within the *Project Information* section, there was sufficient information to identify the hospitals functional and planned project characteristics	4.11	5.00	3.00	0.78
Within the *Project Information* section, the Elements and Sub-Elements are intuitive and simple to use.	3.77	5.00	3.00	0.44
The information given on the *Project Information* page is adequate	3.42	5.00	3.00	0.53
The *Maps and Guidance* section is useful	4.66	5.00	3.00	0.5
The *Sustainability Drivers* section is useful	4.11	5.00	3.00	0.78
The *Associated Guidance* section is useful	4.33	5.00	3.00	0.71
The *Criteria Selection* section is beneficial in facilitating the process of selecting project relevant criteria	4.11	5.00	3.00	0.60
The *Options Selection* section is beneficial in facilitating the process of selecting project relevant options	4.00	5.00	3.00	0.70
The *Decision Support Model* section allows for adequate comparisons to be made between selected criteria	4.00	5.00	3.00	0.50
The *Decision Support Model* section allows for adequate performance ratings to be applied to selected options.	4.33	5.00	3.00	0.86
The *Non-Financial Preference Ranking* chart is a useful feature of the model	4.11	5.00	3.00	0.60
The *Benefit to Cost Preference Ranking* chart is a useful feature of the model	4.55	5.00	3.00	0.52
The Model is of use to the early Business Case process	3.33	5.00	3.00	0.50
The Model is useful in assisting me with the selection of a preferred option	4.44	5.00	3.00	0.52
The range of topics covered in the model is adequate	3.55	5.00	3.00	0.52
The model is useful in identifying best value for Money from selected options	4.11	5.00	3.00	0.78
Efficiency of the Software Platform and the Interface				
The model is easy to navigate	4.55	5.00	3.00	0.52
The models links are intuitive and easy to use	4.22	5.00	3.00	0.44
The model is visually adequate	4.77	5.00	3.00	0.44
Text entry to the model is adequate	3.55	5.00	3.00	0.52
Drop-down menu entry to the model is adequate	4.33	5.00	3.00	0.50
User Satisfaction				
The User Interface is easy to use	4.66	5.00	3.00	0.50
The terminology used throughout the model is clear to understand	3.88	5.00	3.00	0.78
The results of the model appear to be realistic and logical	4.77	5.00	3.00	0.44
The sequencing of the model sections are logical and simple to follow	4.66	5.00	3.00	0.50
My overall impression of the model is that it uncomplicated and user friendly	4.55	5.00	3.00	0.52

Table 7.1.2. Results of the Pilot study

7.2 Main Testing and Validation Phase

It was noted previously, that a limitation imposed upon the pilot study, was that there were no NHS management professionals involved with the exercise. This was justified, as the pilot was heavily focused on format and continuity of the prototype presentation. However; this point also highlighted the criticality of identifying and engaging an appropriate and credible sample population to participate within the main testing and validation exercise. There were two main characteristics that the researcher deemed essential for a balanced and credible process. These were:

1. Suitable selection of panel experts
2. Suitable selection of physical project types

7.2.1 Selecting the Panel Experts

The process of panel selection is closely aligned with the methodology undertaken throughout the identification of sample frame in the main survey. This echoes the requirements set out in the selection of the pilot participants, in respect to the hybrid design of *stratified purposeful* and *criterion sampling* techniques. A non-random selection of research participants therefore, were assessed by virtue of their professional backgrounds and experience. This was key to the main population sample, and this was replicated for the testing and validation. It was critical therefore, to identify and engage professionals from the construction and design oriented disciplines (of whom the PSCPs are generally populated by), but also NHS management professionals, especially from the Estates and Asset management functions. By means of exploring and utilising the professional networks created throughout the research, a total of 23 professionals agreed to participate in the validation process. 13 of these were from a construction/design-oriented background, with a range of experience in various disciplines. The Project Managers and Construction Managers ranged from 12 to 30 years experience, whereas the Cost Managers and Surveyors ranged from 3 to 12 years. The NHS managers were highly experienced, with a range of between 22 and 32 years, in areas as diverse as facilities management, asset management, and estates management. A commonality between all of the invited professionals, was that each had significant experience within healthcare projects, and in fact was currently involved in a healthcare design/construction/refurbishment related project.

There is a significant point in regards to design and process of the testing phase, which differs from the methodological principles used for identification of the main sample population that was approached for the primary data collection exercise. For the testing phase, it was considered preferable, in terms of validity of the results, to design the validation workshops, in a manner that would replicate the actual decision making teams identified as the end users, throughout the literature review, and model development chapters. To this end, the workshops were designed to be undertaken by existing management and project teams, respectively, working on current and live healthcare projects. The discussion therefore, was grounded in an environment of participants and professionals, whom were (in the main) known to each other, and approaching the exercise form a common starting point. This negated any possibility of misunderstanding in the workshop preamble, in terms of the participants mentally 'placing' themselves, into a project-focused environment.

Although the scoring feedback forms were anonymous, the linear demonstration style of the workshop, and the interaction from the participants as a whole, allowed for a natural and fluid discussion to taken place, in the same integrated and hierarchical environment, as that which the group would be accustomed to within their normal routine. Given that a fundamental objective and requirement of the functioning prototype, was the pursuit and achievement, of a standard of consensus, this 'real life' technique proved to be very successful in regards to participation, and a smooth flow of the workshop activity.

It was highlighted earlier, in the discussion on the pilot study, that the intention of the feedback and scoring forms, were not to identify each individual disciplines responses. It is reiterated, that this is supported and justified, by the integrated nature of the prototypes purpose (and this is itself, supported by the decision to group the workshops into existing project teams, as discussed above) this may be seen as a limitation to the study, however, for the purposes of the data requirements, this depth of filter is viewed as being wholly correct for these purposes. Despite this deliberate parameter, it would nevertheless be an informative exercise, to analyse the results by professional discipline, and this is noted as a potential recommendation as part of a more specific and focused, research excercise.

7.2.2 Selecting the Physical Projects

A number of projects were considered across NHS Scotland. It is reiterated that a limitation of the research scope, was to consider projects within Scotland. Again; this was discussed previously, and is driven largely by the differences in procurement routes and business case procedures between NHS Scotland, and the rest of the UK. A total of 3 separate projects were identified. It may be more accurate to say that 3 'teams' related to projects were identified, as (especially in respect of the NHS managers), individuals were involved with a range of projects across various facilities. Project 'A' was a £21m refurbishment project of an acute hospital building. Project 'B' was a £29m new build project of an integrated health centre, and Project 'C' was an £11m refurbishment and reconfiguration of care services in a large regional acute hospital. All 3 projects were subject to business case protocols as required by the Scottish Government, and as such, each was identified as having a key duty to identify, and pursue, best Value for Money, as far as practicably possible. The testing presentation was delivered on the case study facility (Project 'A') although advance discussion was carried out with all participants to ensure focus was given to the prototypes functionality on 'a' project. An open discussion was carried out within all 3 selected project teams, following each presentation. Although the case study project provided discussion points on the mechanics of the prototype itself, the teams very quickly (and with little difficulty) were able to discuss the application of the prototype, in the context of their own site-specific scenarios.

7.2.3 Main Validation Results

Table 7.2.2 shows the results of the main validation exercise following the testing phases. It is reiterated that these results are a composite of 3 separate project teams and project groups. The NHS managers and the PSCP professionals have also been measured and analysed together, as this reflects the integrated nature of the project teams. This mirrors the methodology used throughout the main data collection excercises as discussed in the methodology chapter.

	Effectiveness for intended use	Mean	Max	Min	SD
1	Within the *Project Information* section, there was sufficient information to identify the hospitals functional and planned project characteristics	4.39	5.00	2.00	0.58
2	Within the *Project Information* section, the Elements and Sub-Elements are intuitive and simple to use.	4.43	5.00	2.00	0.58
3	The information given on the *Project Information* page is adequate	4.17	5.00	2.00	0.38
4	The *Maps and Guidance* section is useful	3.73	5.00	2.00	0.44
5	The *Sustainability Drivers* section is useful	4.13	5.00	2.00	0.54
6	The *Associated Guidance* section is useful	4.34	5.00	2.00	0.50
7	The *Criteria Selection* section is beneficial in facilitating the process of selecting project relevant criteria	3.95	5.00	2.00	0.36
8	The *Options Selection* section is beneficial in facilitating the process of selecting project relevant options	4.13	5.00	2.00	0.45
9	The *Decision Support Model* section allows for adequate comparisons to be made between selected criteria	4.17	5.00	2.00	0.49
10	The *Decision Support Model* section allows for adequate performance ratings to be applied to selected options.	4.26	5.00	2.00	0.54
11	The *Non-Financial Preference Ranking* chart is a useful feature of the model	4.17	5.00	2.00	0.65
12	The *Benefit to Cost Preference Ranking* chart is a useful feature of the model	4.56	5.00	2.00	0.50
13	The Model is of use to the early Business Case process	3.91	5.00	2.00	0.51
14	The Model is useful in assisting me with the selection of a preferred option	4.30	5.00	2.00	0.55
15	The range of topics covered in the model is adequate	4.08	5.00	2.00	0.51
16	The model is useful in identifying best value for Money from selected options	3.73	5.00	2.00	0.54
	Efficiency of the Software Platform and the Interface				
17	The model is easy to navigate	4.17	5.00	2.00	0.38
18	The models links are intuitive and easy to use	4.08	5.00	2.00	0.41
19	The model is visually adequate	4.08	5.00	2.00	0.28
20	Text entry to the model is adequate	3.73	5.00	2.00	0.44
21	Drop-down menu entry to the model is adequate	4.26	5.00	2.00	0.44
	User Satisfaction				
22	The User Interface is easy to use	4.08	5.00	2.00	0.28
23	The terminology used throughout the model is clear to understand	4.00	5.00	2.00	0.00
24	The results of the model appear to be realistic and logical	4.17	5.00	2.00	0.49
25	The sequencing of the model sections are logical and simple to follow	4.13	5.00	2.00	0.34
26	My overall impression of the model is that it uncomplicated and user friendly	4.17	5.00	2.00	0.38

Table 7.2.2. Results of the main validation

What is shown in Table 7.2.2 is that the maximum and minimum result parameters are 5 and 2 respectively. Mean scores are shown, and analysis variance is described by illustrating the standard deviation scores on each question. A significant average mean score was calculated at 4.66. Correspondingly, the average standard deviation scoring was 0.5, which indicates a relatively small spread of results recorded form the Likert scale questionnaires. This signifies a general degree of consensus from the respondents across the questionnaire, and mirrors the results from the pilot study. Although the results signify a positive response from the testing and validation group, it is of note that one of the weakest areas was identified in the question regarding utility in proving Value for Money. This was backed up by qualitative input on the question sheets by comments that as the costs required for the models Benefit to Cost calculation function, were not clearly defined in regards to type (i.e. total costs, materials only etc.) then this was vague point. However; it is highlighted that the brief to all participants prior to the testing phase, specifically clarified that the costs could be input in many different ways (works, material only, full life-cycle costs etc.) as long as the convention was maintained throughout the entire modelling process. This point did however, signify the importance of developing a consistent and applicable costing function to the prototypes future development.

7.3 Chapter Summary

The main feedback in regards to post-testing and validation discussion, was very positive in terms of prototype format and intuitive design. Criticism received was focused primarily on a post-prototype set of issues. These included concerns over the resourcing of the prototype if it was developed for use within industry. The large number of reference documents and guidance which populate the model, are in PDF format, and participants queried whom would be responsible for the upkeep and stewardship of such a volume of documents. It was discussed that a future working model, would be largely integrated by means of web based links as opposed to PDFs, and thus would be updated by default, as long as the source web links themselves were updated by the document/resource owner.

Application of costs were also flagged up as an area of priority. The Benefit to Cost ratio technique used within the prototype, was welcomed as providing 'some form' of cost appreciation and ranking, although the limitations of this method were apparent. As with the discussions regarding resource, it was explained that a major limitation to the model in terms of costing, was that a separate Life-Cycle Costing worksheet is identified, to populate the costs column in the decision-making matrix. It was discussed that the model would be applicable, in the main, to high cost or clinically sensitive elements, sub-elements, or components, and this supports the commonly accepted usage of Life-Cycle Costing techniques which also target only suitable items, governed largely by cost or importance.

CHAPTER EIGHT DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

8.0 Discussion

The discussion section has been shaped by the deductive and inductive, or mixed methods, approach, which has been examined in great detail in the methodology chapter. What is meant by this, is that although the objectives and the research questions themselves will be discussed, there are aspects of the models development which have only come to light as the research has progressed, and the prototype been designed. A structured approach is presented in addressing each objective and research question. Therefore; each objective and research question is discussed in sequence below, and referenced to the main body of the thesis.

8.1 Objectives

Each objective is summarised as follows:

8.1.1 Review the integrated nature of the hospital in the context of sustainability driven refurbishment requirements

Using primarily secondary data collection techniques, the literature review has presented the integrated nature of the hospital, the sustainability model, and the challenges of the refurbishment process. A key finding as part of this process, was that the challenges of hospital refurbishment in the context of sustainable development, is a largely under-researched area. The UK economic downturn, stemming from circa 2006 onwards, has changed the landscape of investment and capital expenditure with great rapidity. Given the backdrop of demanding institutional and statutory sustainability targets, which were enacted into legislation *prior* to the economic downturn, the effect on the connectivity between the 3 aspects stated above, and the willingness or capacity, of the NHS/PSCP stakeholders to initiate projects, a definitive gap in both investment and research has appeared in the field. The literature review in this context, explored the current state of the art, and identified challenges, which were applicable to both the NHS built estate, and the requirement to maintain a functional and adaptable clinical service delivery model.

8.1.2 Explore the range of related sustainability assessment methodologies and model types and consider these in the context of the NHS

A high level to project level approach was taken in exploring the range and efficacy of sustainability assessment models. A broad range of methodologies and systems were reviewed and compared, and it was generally considered that the motivations behind sustainability assessment were positive in the sense that a framework or structure is applied to guide or signpost relevant actors. It was apparent however, that the NHS lacks flexibility in this area, which may justifiably be viewed as part of the problem, as opposed to part of the solution. This is especially noticeable in the context of the refurbishment activity. As a condition of funding release (on projects in excess of £2m in value), the Client and Design Team are immediately faced with the requirement to achieve a set BREEAM rating. This was explored in greater detail throughout the primary data collection phase, and a highly significant finding in this area, is that the BREEAM assessment, although mandatory, is completely inappropriate and unsuitable for refurbishment projects (and especially on a facility as potentially complex as the hospital) This key point seemed to support the requirement to develop a specification and selection model for systems, elements, and components, which was flexible enough to consider the refurbishment project, on a case by case basis, driven by the unique characteristics of the facility in question.

8.1.3 Investigate Environmental Management Systems and consider these in the context of the NHS

The EMS was considered using the same methodology as that of the sustainability management systems. A high level down approach was used to provide context and frame the structure and purposes of relevant systems. Although generally viewed as positive in their intention, the EMS also attracts criticism on it's 'self designed' structure. The concept of allowing the implementer of the system to set their own targets and policy statements, opens the way for designing the process to ensure successful achievement of targets, rather than setting real challenges, which would require resource, finance, and commitment, to achieve. However, the systemic nature of the EMS offers a positive contribution by providing a framework. Additionally, the ISO 14001 suite, are highly compatible with sister systems such as ISO 9001 Quality Assurance. The relevance to the requirement for a developed model is oblique, although still relevant in the criterion and potential options selection stages.

8.1.4 Examine the phenomenon of decision-making as an activity, and assess its application in the context of the business case process

Decision-making as an activity was explored in detail. What was immediately apparent, was that the range of decision-making models, and the areas of use was vast. Before looking at models in technical detail, it was highlighted that decision-making as an activity is embedded throughout every aspect of life. The decision-making paradox was identified as an unavoidable aspect of model selection (this suggests that to derive a suitable decision-making process, a decision-making process must be undertaken) In context of the research, multi-criteria decision modelling (MCDM) techniques were identified as most appropriate. A middle ground between identifying a methodology which could compare and rank multi (often competing) criteria and options, and a manageable framework (by means of discrete MCDM techniques) was required. This objective also shaped subsequent objectives, in highlighting the requirement to understand the current decision-making processes used throughout the NHS refurbishment process. This opened up the research requirements into the area of asset and estates management, and the crossover points with the PSCPs undertaking work as part of the standard business case process. Secondary and primary research techniques were used in reviewing the models themselves, and also illustrating the current processes used, and the NHS/PSCP awareness and experience of MCDM processes. The general knowledge base regarding MCDM techniques, was found to be very small. This opened the research objectives up to exploring and identifying the gaps in process and knowledge, which ultimately shapes the original contribution to knowledge.

8.1.5 Understand and present the capital investment and asset management processes, applicable to the NHS, and to describe their relevance and position within the refurbishment process, and the decision making function

Shaped (as discussed previously) by the developing primary and secondary data collection excercises, the key transition or interface points between the NHS and the PSCPs, was identified as the standard business case process. The over-arching guidance for the business case, was identified as stemming from the capital investment guidance, and also the property appraisal guidance documentation within the NHS. The decision was taken to review these in a stand-alone chapter titled the 'contextual background'. The justification for this was on the basis of these issues being deemed outside of the normal literature review process. The chapter is very much focused on the technical operation of the tools and systems, and academic publications specifically describing these areas are very limited. This itself, illustrates a potential gap in the research canon, and may be related to the rapidity of change in investment and attitude to the NHS as described earlier in the chapter. The existing decision making processes (in as much as they exist) were reviewed, and the mandatory guidance and documentation was filtered out for consideration in developing an integrated and compatible decision support prototype. The key outcome of this objective, was the identification that it was within this area, or more correctly, in the transition and interface points between the NHS and the PSCPs, that the original contribution was best placed to be addressed. Identifying the gap within the subsequent model development was therefore driven, largely, by a detailed review and interpretation of the tools and systems in use.

8.1.6 Design a conceptual decision support model with the help of secondary data collection

This was achieved primarily through the detailed review of the range of decision making models described earlier, and by building parameters to the ultimate prototypes intended use. The entire model development process is presented within the thesis in a stand-alone 'model development' chapter. Critical reflection on the target decision-making group, and the intended outcomes of the model formed a large part of the conceptual development. The model was published in a peer-reviewed paper, and presented at an academic conference to test the concept.

8.1.7 Design a decision support framework with the help of both secondary and primary data collection excercises

The interim phase of developing the prototype, required the tested conceptual model, to be transposed into a working framework. This was presented in matrix form, by use of weighted evaluation techniques. The advantages and limitations of this are described in detail within the chapter, but the key objective of this stage was to test the mathematic functionality of the framework prior to future final development. The framework was presented to 3 separate audiences. The first consisted of senior level asset and estate managers from the NHS. The second was a PSCP team on a live refurbishment healthcare project. Then third was at an industry conference with assorted sustainability and design team professionals. The structure and design were deemed to be sound in all cases. Building on from earlier objectives, it was the framework development phase which definitively identified the intervention and integration point of the developing prototype. The gap in the current processes (and therefore 'knowledge') was clearly highlighted within this objective.

8.1.8 Develop a functioning software based, decision support prototype, built from the conceptual and framework design processes

Having tested the working framework, and identified the gap, the final output requirement was the development of the functioning prototype. Although secondary data sources were key to signposting potential options for design, an in-depth primary data collection exercise was undertaken to identify the most suitable software platform, and also the level of technical and guidance content within. On the dual basis, od compatibility with current systems, and user familiarity with the software, the MS Excel platform was identified. The nature of the calculations required for the model, and the background coding required to enhance the user-friendliness of the prototype, were both satisfied easily with Excel. A seminar was conducted with an academic audience, to present the developing prototype in regards to usability and format. Relating back to the primary data collection, it was viewed as a priority form the sample population, that any system or tool, would require to be visually simple. By means of a user friendly Graphical User Interface (GUI), and also easy to use, by means of drop down menus and links to key documents and guidance. The final prototype was developed, and with relevant permissions received in writing, a live healthcare refurbishment project was uitlised as a case study demonstration of the functioning prototype.

8.1.9 Test and validate the completed decision support prototype with industry experts and potential model user groups.

The ultimate *physical* objective (or output) of the research, was to develop a complete and functioning prototype, which satisfied all of the previous objectives, and had integrative capacity with the existing tools and systems. This was achieved by means of the process described in the model development chapter. This final step brought together a significant volume of the secondary and primary data collection excercises. It was critical however, to test and validate the model with identified industry panel experts, and this is illustrated within the testing and validation chapter. The overall feedback from the participants was very positive. This is clearly demonstrated by means of the statistical modelling of the main questionnaire, indicated by the high average scoring in each category, and the relatively small standard deviation between responses. Discussion is undertaken at the summary of the testing and validation chapter, although some key points are worth reiterating. In regards to limitations of the prototype, it was felt by the participants that the model did not necessarily assist the process in achieving value for money. However, it was observed that the prototype did assist in proving that value for money had been pursued as an objective, and that this process benefitted from being recorded in a structured format. Although, on the face of it, the difference between these two issues centering around value for money may seem slight, this is not necessarily so. Upon further discussion, it was found that the core reason for this differentiation from the testing and validation groups, was that value for money itself is such an ambiguous and non-parametric term. This was accepted as constructive criticism for the testing, although reference was made to the primary data collection exercise carried out previously, which qualitatively modeled the main sample frames definitions of what they perceived value for money to be. Overall, the testing and validation exercise was found to be successful, and the prototype was accepted by potential professional users as a technique they would be willing to use on ongoing and future healthcare refurbishment projects. The sustainability dimension to the model was discussed in terms of applicability, but again, reference was made and discussion ensued on the triple dimensional nature of the wider sustainability model, and that in effect, most aspects of a typical healthcare refurbishment project were subject to conditional drivers associated with the environmental, social, and economic aspects.

8.1.10 Summary of Objectives

The objectives have been discussed in summary detail, highlighting, where applicable, the key points or findings associated with each. The structure of the thesis chapters in which each objective is referenced, presents much of the discussions within the text. Therefore, the key points discussed above, must be read in conjunction with the embedded text for close detailed discussion.

8.2 The Research Questions

The thesis contains 2 main research questions, each with a further sub-set of 3 questions, which were required to address each main question. The research questions are situated within the results and analysis chapter, and discussion on each is undertaken against each one at that point. The primary data collection was very influential in addressing the research questions, and this is demonstrated clearly within the chapter. It is noted however, that not all of the results of the primary data collection exercise are relevant directly, to answering the research questions, but as described within the objectives section earlier in this chapter, there are many areas where the wider results have proved instrumental in shaping and designing the prototype, and understanding the potential decision makers. This is evidenced in areas such as familiarity with software platforms, familiarity with key documentation, and subjective questioning on the ranked importance of sustainability issues, and public involvement in design level decisions (respectively). The full results set are placed within the appendices for reference. The research questions are reiterated below.

8.2.1 Research Question 1

Is there a requirement for a decision support model for undertaking sustainable refurbishment of hospital and healthcare buildings?

M. Do current tools and processes identify areas of priority in identifying key decision making criteria?
N. Do current tools and processes offer a best option, or alternative for the project, based on 'project specific' criteria?
O. Is there a formalised management/facilitation process, that ensures that a rigorous and demonstrable decision making process has been undertaken? (within the mandatory institutional requirement to demonstrate Value for Money)

8.2.2 Research Question 2

Are Multi Criteria Decision Making techniques applicable to the undertaking of sustainable refurbishment of hospitals and healthcare facilities?

P. What is the level of knowledge and application of MCDM techniques in regards to the current Business Case process?
Q. Are MCDM techniques compatible with the existing systems and processes used within the current Business Case process?

R. Can the use of MCDM modeling techniques, demonstrate that Value for Money has been achieved as far as reasonably practicable, specific to the project in question?

8.3 Contribution to Knowledge

This is described in context, in the relevant section of chapter 6, which presents and discusses the complete development process of the model, from concept to prototype. However; the main contribution is reiterated.

The contribution to knowledge is multi-faceted. In a technical sense, the research and the functioning prototype, bridge an existing gap between the currently used estate management tools and systems, and the specification choices prioritised as part of the standard business case process. It has been shown that the existing systems from the NHS asset and estates management perspective, identify, prioritise, and cost, key refurbishment activities which are required as a result of the backlog maintenance needs. These prioritised backlog maintenance issues are subsequently brought forward into the standard business case process, which is also the point at which the Principal Supply Chain Partner (in the context of a Framework arrangement) interfaces with the potential refurbishment project. Currently, the PSCP is placed in a position of addressing the prioritised backlog items, within the parameters of a set budget. The decision-support prototype has been developed and tested so that it is integrated into the process at this point. The model builds upon and improves the existing estate management systems prioritised and costed refurbishment and maintenance actions. This provides a user friendly and integrated mechanism for deriving the best-fit option, specific to the projects unique business case criteria.

The technical dimension described above, is largely focused on bridging the existing gap in the knowledge and existing processes. From a related, yet subtly different perspective, the original contribution in the philosophical sense, targets the actual decision-making process and interaction between the various key actors involved across the refurbishment process. The linear characteristic of the entire process, from the initial property appraisals, through to the standard business case, creates a scenario where the NHS strategic management aims (and the asset and estates management actors involved) take precedence in the early stages, and the PSCP involvement is introduced relatively late in the process by means of the standard business case required for physical works to commence. Relating back, to the technical 'bridge' described above; the optimum opportunity for integrating the prototype within the current systems, and the optimal intervention point for use within the business case has been demonstrated as the transition from the Initial Agreement to the Outline Business Case. This promotes greater interaction and communication between the NHS and the PSCP. The criterion and options 'layered' selection process, and the use of pairwise comparison decision-making techniques in agreeing unambiguous consensus based on subjective and objective platforms, introduces a more inclusive communication (and therefore decision-making) methodology to the current process.

8.4 Conclusions

The main purpose of the research was to carry out an in-depth study of the current practices and challenges faced in regards to the sustainable refurbishment of hospitals and healthcare facilities. A key output, was the development and testing of a functioning prototype to guide and support the decision making process, integrating the NHS and the PSCP actors. Overall, these have been achieved, however there are key points to note in addition to the objectives, contribution to knowledge, and research limitations already discussed. These are summarised as follows:

1) The National Health Service built estate has been identified as a vast and complex portfolio. It has been clearly identified that the age, condition, and typology, of building types, places the NHS in an extremely challenging situation practically and financially, in ensuring that a fit for purpose and adaptable service is maintained and operated. The economic downturn has had major implications on the ability and capacity of healthcare authorities to invest the required amount of money needed to maintain such a wide estate. This has direct implications on the ability of the estate to cater for

the actual clinical requirements embedded within the models of care.

2) Demanding sustainability targets face the NHS, at a time when there are mandatory requirements for health authorities to find and implement significant efficiency savings. Investment which may have been available pre-economic downturn, has become increasingly more scarce as capital budgets have shrunk and projects been cancelled and/or delayed. The emphasis to demonstrate that Value for Money has been both pursued and achieved, has become more prioritised. Currently however, no standardised or structured format exists which facilitates this process.
3) Multi-criteria decision making (MCDM) techniques are not commonly used nor understood by the NHS and the PSCPs. Given the potential complexity of the business case and the activity of refurbishment, this has directed the research to explore these techniques in greater detail and application. The broad spectrum of experience levels and professional disciplines involved with healthcare planning and refurbishment projects, has illustrated that MCDM provides a structured framework to engage and integrate the decision-making teams.
4) A functional decision support prototype has been developed, which uses discrete MCDM techniques, and is focused on facilitating and integrating the various decision-making actors at the optimum point in the business case process. The transition point from the Initial Agreement to the Outline Business Case has been identified as the key stage for the prototypes use. The design of the prototype allows for the decision-makers to select and evaluate criteria, specific to the unique business case.
5) A process of testing and validation was carried out with NHS and PSCP professionals and managers, whom are all currently involved with healthcare refurbishment projects. This process has played a critical role in evaluating and field testing the prototype, with a view to future development. The panel experts described above, were

overwhelmingly positive in regards to the credibility and applicability of the model on healthcare refurbishment projects.

8.5 Limitations of the Research

The nature of the subject area and the research techniques presented clear limitations to the research. The structure of the thesis presents multiple areas of focus, and as such, the limitations for each are most clearly described under separate headings.

8.5.1 Limitations in Scope

It was quickly apparent when designing the literature review process, that the research demanded coverage of multi-dimensional facets. In summary, this included researching the sustainability model, the hospital, and the refurbishment process. This presented a vast amount of material, which was completely impractical to attempt covering in its entirety. Even when considering the NHS within the UK, the differences in legislation, governance, and procurement routes for capital investment, resulted in an unmanageable research focus, given the time and resource limitations of the research project. It was therefore deemed appropriate, to focus specifically on the refurbishment of hospitals and healthcare facilities in the context of NHS Scotland *only*. Given the significant changes to the NHS in England, and the complete restructuring by means of the *Health and Social Care Act 2012*, which were being implemented on a parallel time frame with the research project, a potentially rich and contemporary area of research had to be discounted. Similarly, the use by NHS Scotland of a limited number of procurement paths, narrowed the focus of the research to consider the standard business case in the context of Framework agreements. The focus on Frameworks was a further limitation *within* the NHS Scotland procurement options. Given that the structural basis for the prototypes development (and the original contribution) was the standard business case process, as presented within the *Scottish Capital Investment Manual* (SCIM), other approaches such as the *HUBCO* agreements were not considered. This is an important limitation to highlight, as the nature of NHS Scotland strategic aims, in terms of rationalisation of the built estate, and the evolution of care delivery models themselves, are utilising these procurement agreements with greater frequency. A final key observation of scope limitation, must be identified of the choice of facility itself. The nature of the estates management process, and the subsequent standard business case process, incorporates capital investment considerations on all healthcare related facilities across the entire NHS Scotland built estate. Again; due to constraints in time and resource, it was impractical to cover all healthcare facility types, and therefore the acute hospital was selected as the exemplar facility, supported by the fact that it is the most complex, utilised, and multi-faceted asset type across the whole estate.

8.5.2 Limitations in Data Collection

The data collection limitations are directly related to the earlier discussion on the requirement to narrow the research to Framework agreements within NHS Scotland. For the main primary data collection exercise, and the eventual testing and validation of the functioning prototype, it was therefore necessary to limit the participants and invitees to NHS managers and PSCP professionals, whom were involved within these parameters. The pilot study for the main questionnaire was distributed across the UK, and potential live projects were identified which would have provided good exemplars for the ongoing research. However, the aforementioned differences in governance and procurement structures, would have created a disconnect between the reference guidance documents, and the project in question. The main questionnaire and interview construction, was therefore designed around the Scottish dimension. It became apparent also, that the range of issues and guidance relating to the estates management and business case processes was vast, and that only key documents (identified throughout the literature review and secondary data collection excercises) could be included. This narrowed the area of research to focusing on the end phases of the property and appraisal processes, and the early phases of the business case. Given that these stages were identified as the optimum intervention points, this created no significant issues, although the sample frame itself was narrowed to include only participants whom were likely to be involved within these boundaries. Although this was positive in the sense that the sample frame could be specifically targeted, therefore providing a potentially far richer and meaningful data set, the professional groupings were fairly well defined in terms of discipline. Involvement of commercial managers or cost consultants may have been beneficial, as would (potentially) expert sub-contractors specialising in a certain system, element, or component.

8.5.3 Limitations to the Prototype

It is a key consideration to re-emphasise that the physical software output is indeed a 'prototype' and not intended as a complete and finished product. The terms 'prototype' and 'model' have been used inter-changeably throughout the thesis, however it is clear within the text, that the context refers to the same outcome. Although the testing and validation results were found to be largely positive, it was identified that the prototype in its current form would require resource to maintain and operate. The design of the prototype combines both web based links and PDF links, although the PDF links are far greater in number. A result of this, is that when guidance and documentation which are currently embedded within the master file structure are amended or superseded, then the prototype is effectively out of date in that regard. These points were accepted as wholly valid, and it was discussed that a future operational model, would be linked to all main documentation and reference sources via web links, and therefore updated by default. A significant limitation to the prototype, relates to the final decision-making matrix page, and the inclusion of costs and financial ranking calculations. Financial preferences are recognised within the model, however, the benefit to cost ratio technique employed is itself limited in scope. Ideally, the cost values should be a result of a separate Life-Cycle Costing exercise, using discounting techniques and net present values, however time and resource constraints for the research did not allow for this function to be explored and designed in greater detail.

8.6 Recommendations for Future Research

It has been highlighted throughout, that the physical output of the research project has been the functioning decision support prototype. It has also been identified, that there are future development opportunities for the model itself, which could improve its functionality and application; a key recommendation being the development and improvement of the costing function to calculate full Life-Cycle Costing values.

However; the development of the prototype is only a single aspect of the potential for further research. Many of the recommendations are aligned with the earlier discussion on the limitations of the research. On a broad level, it was identified throughout the literature review process, that research into the area of hospital refurbishment in the context of sustainability, was limited. Given the clear indications that investment into new build, and even refurbishment and maintenance projects, has been severely curtailed, it seems logical and necessary that the research canon in this area is expanded.

The NHS and its asset management and estates functions, are bound (in the context of physical works) by assessment methodologies and guidance which seem in many cases to be inappropriate for the changed investment landscape. In the context of healthcare refurbishment, the industry assessment bodies have been slow to react in modernising the current methodologies and developing newer and more flexible tools. This area itself, opens up a whole area of research which would seek to find a credible and acceptable balance between optimising the sustainability performance of a facility, and allowing for site specific considerations such as existing orientation, form, or function, to be factored in.

Again, in reference to the limitations section discussed previously; the changes in governance and service provision/provider rules relative to the English NHS, could direct the research focus, and any developments to the prototype, in significantly different directions. The interface between the private sector and the public sector, presents a brand new dimension to the delivery of care within the NHS (England) which has as yet, been untested. The existing relationships between the NHS and the Designers and Constructors (by means of various PPP/PFI etc. procurement routes) have been the cause of much research and criticism in the past, and it could be informative to re-visit the overall public/private relationship going forward.

Finally, in regard to the NHS Scotland procedures and systems featured as the platform for the thesis, the entire business case is open to further research to assess if any improvements could be made to the existing process. Using the prototype as one aspect of this (or an improved and modified version of it), the linear nature of the business case process, and the staggered intervention points of various key actors could be reviewed. This is supported by NHS Scotland and the Scottish Governments own commitments to rationalisation of the NHS estate and care delivery models, and the desire to maximise the integration opportunities between all stakeholders of the Scottish National Health Service.

References

- A whole building' path to climate control. 2010. *Health Estate Journal* [online] Available from: http://healthestatejournal.com/print.aspx?story=7383 (Accessed 10/07/13)

- Achieving Excellence Design Evaluation Toolkit (AEDET) [Online] Accessed: 10/07/13. Available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_082089

- *Activity Data Base*. Space for Health: Information for Healthcare Premises Professionals. Accessed: 10/07/13 Available at: https://publications.spaceforhealth.nhs.uk/index.php?option=com_content&view=article&id=57&Itemid=9

- Aho, T., Laatio, P., Lamsa, J., 1998. *Refurbishment Investment Appraisal*. Proceeding of International Symposium on Management, Maintenance, and Modernisation of Building Facilities, 18-20 Nov. Singapore, pp. 237-242

- Aikivuori, A., 1996. *Periods of Demand for Private Sector Housing Refurbishment.* Construction Management and Economics, Vol. 14, pp. 3-12

- Al-Hajj, A (1991) *Simple Cost Significant Models for Total Life-Cycle Costing in Buildings*. PhD Thesis. Department of Civil Engineering. The University of Dundee

- Alanne, K. 2004. *Selection of Renovation Actions using Multi-Criteria "Knapsack" Model*. Automation in Construction 13. Pp. 377-391

- Allane, K., Ahti, A., Arto, S., Gustafsson, S. 2007 *Multi-criteria evaluation of residential energy supply systems* Energy and Buildings. 39 pp. 1218-1226

- AMA Research (2010) *Characterising the Market for Refurbishment Works in the Built Environment* Final Report. The Waste and Resources Action Programme. Banbury. UK

- Amaratunga, D. Baldry, D. Sarshar, M. Newton, R. (2002) *Quantitative and Qualitative Research in the Built Environment. Application of Mixed Research Approach.* Vol. 51. No. 1. Work study pp. 17-31

- Andrew, A and Pitt, M. (2004) *Property Appraisal in Government*. Journal of Property Investment and Finance. Vol. 22 No. 2 pp. 192-199

- Azlan-Sha, A., 2010. Design Information in Managing Refurbishment projects in Malaysia. International Journal of the Physical Sciences. Vol. 5(6) pp. 768-773, June 2010

- Balanced Scorecard Institute [Online] *The Deming Cycle* Accessed: 10/07/13. Available from: http://www.balancedscorecard.org/TheDemingCycle/tabid/112/Default.aspx

- Belton, V., Stewart, T, J. 2002 *Multiple Criteria Decision Analysis: An Integrated Approach.* Kluwer Academic Publications. Boston MA. USA

- Beyond, D., 1990. *Information and Data Modelling.* Alfred Waller ltd, Henley on Thames. UK.

- Bibby, L., Bouchlaghem, D., Austin, S., 2003. *Design Management in Practice: Testing a training initiative to deliver tools and learning.* Construction & innovation. 3. 217-229

- Black N, Gruen R., 2005. *Understanding health services.* Maidenhead. Open University Press.

- Boyd, E and Tompkins, E, L (2010) *Climate Change* Oneworld Publications. Oxford

- Bouyssou, D. Marchant, T. Pirlot, M. Perny, P. Tsoukias, A. Vincke, P. 2000. *Evaluation and Decision Models: a critical perspective.* Kluwer Academic publishers. Massachusetts. USA

- Brand, S. 1994 *How Buildings Learn: What happens after they're built* Phoenix Illustrated. London

- Braunshweig, T. Jannsen, W. Rieder, P. 2001. *Identifying Criteria for Public Agricultural Research Decisions.* Research policy 30 (2001) pp. 725-734

- BREEAM for Healthcare 2008. *Building Research Establishment.* BES 5053: issue 3.0. BRE Global. Watford. Hertford-shire

- Brewer, R (2007) *Your PhD Thesis. How to plan, draft, revise, and edit your thesis* Studymates Limited. UK

- BBC News Online[1] *Lehman Brothers file for bankruptcy* Accessed: 10/07/13 Available from: http://news.bbc.co.uk/1/hi/7615931.stm

- BBC News Online[2] *NY alert over post-storm housing* Accessed: 10/07/13 Available from: http://www.bbc.co.uk/news/world-us-canada-20123727

- BBC News Online[3] *Phillipines: Typhoon Bopha death toll rises* Accessed: 10/07/1Available from: http://www.bbc.co.uk/news/world-asia-20604423

- British Broadcasting News Channel., 2007. *Climate skepticism: the top 10*. [online] Accessed. 10/07/13 Available from: http://news.bbc.co.uk/1/hi/in_depth/629/629/7074601.stm

- British Broadcasting News Channel., 2010 [online] Accessed 10/07/13 Available from: http://www.bbc.co.uk/news/health-11984036

- British Standards Institute [Online] *BS EN 16001:2009 Energy management systems. Requirements with guidance for use* Accessed: 10/07/13 Available from: http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030172146

- Building Research Establishment (2009) *BRE Environmental & Sustainability Standard: Healthcare Assessor Manual* BES 5053: Issue 3.0 BRE Global

- Building Research Establishment (2008). *A Discussion Document Comparing International Environmental Assessment Methods for Buildings.* BRE Glasgow

- Burer, M., Tanaka, K., Yamada, D., Favrat, D. 2003 *Multi-criteria optimisation of a district cogeneration plant integrating a solid oxide fuel cell-gas turbine combined cycle, heat pumps and chillers* Energy 28. Edition 6. pp. 497-518

- Burke, R., 2006 *Project Management: Planning and Control Techniques* John Wiley & Sons. Chichester pp.14

- Carbon Reduction in the NHS: A Role for Finance. 2009., *HFMA briefing document.* Contribution to the debate on NHS finance.

- Carbon Trust, 2010. *Hospitals: Healthy budgets through energy efficiency.* London. HMSO

- Carter, J, G. (2011) *Climate change adaptation in European cities* Current opinion in Environmental Sustainability 3 pp. 193-198

- Chaudhary H, Mahmood A, Valente M., 2006 Nurses perception of single occupancy versus multi-occupancy rooms in acute care environments: an exploratory assessment. *Applied Nursing Research*, Vol 19: p.118-125

- Chew. M, Y, L. DAS, S. 2007. *Building Grading Systems: A Review of the State of the Art.* Architectural Science Review. Vol. 51. 1 pp. 3-13

- Clements, R, B., 1996 *Complete Guide to ISO 14001* Englewood Cliffs NJ. Prentice-Hall

- Climate Change Act 2008. [online] Accessed 17/12/10. Available from:

- Cobb, T. (2006) *Constructivism* Encyclopedia of Language & Linguistics. Elsevier. pp. 85-87

- Cohen, J (1990) *Things I Have Learned (So Far)* American Psychologist. Vol. 45 No. 12 pp. 1304-1312

- Collins English Dictionary. 1988. William Collins & Son. Glasgow

- Corbett, C, J. KIRSCH, D, A., 2001 *International dispersion of ISO 14001 certifications.* Production and Operations Management 10 (3) pp. 327-342

- Cresswell, J, W. (1998) *Qualitative Inquiry and Research Design. Choosing among five traditions* Sage Publications. London

- Dahl, A, L. 1996. *Measuring the Unmeasurable.* Human Settlements. Our Planet. Vol. 8. ed 1.

- De Boer, J., Wardekker, J, A., Van der Sluijs, J, P. (2010) *Frame Based Guide to Situated Decision Making on Climate Change* Global Environmental Change 20 pp. 502-510

- DEFRA 2011. *Accounting for sustainability in government 7 Jan 2011.* [online] Accessed:. 10/07/13 Available from: http://sd.defra.gov.uk/2011/01/accounting-for-sustainability-in-government/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+gov%2Fsdscene+%28SD+Scene%29

- Denzin, N, K (1970) *The Research Act in Sociology: A Theoretical Introduction to Sociological Methods* Butterworths. London

- Department of Energy and Climate Change [Online] *Carbon Reduction Commitment Energy Efficiency Scheme.* Accessed: 10/07/13 Available from: http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/crc/crc.aspx#more_about_CRC

- Department of Energy and Climate Change. [Online] *CRC Energy Efficiency Scheme* Accessed: 10/07/13 Available from: http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/crc/crc.aspx

- Department of Health (2009) *Environment and Sustainability. Health Technical Memorandum 07-07. Sustainable Health and Social Care Buildings.* London. The Stationery Office

- Devuyst, D. (ed). (2001). *How Green is the City?: Sustainability Assessment and the Management of Urban Environments.* New York: Columbia University Press.

- Ding. G. K. C. 2007. *Sustainable Construction- The Role of Environmental Assessment Tools.* Journal of Environmental Management 86 pp. 451-464

- Douglas, J. 2006 *Building Adaptation* Butterworth-Heinemann. Oxford. 2nd Edition.

- Eccleston, C, H. Smythe, R, B., 2002 *Integrating Environmental Impact Assessment with Environmental Management Systems* Environmental Quality Management. Summer Edition pp. 1-13

- Edinburgh Centre for Carbon Management [Online] Accessed: 10/07/13. Available from: http://www.eccm.uk.com/httpdocs/index.htm

- Edwards, N. Harrison, A., 1999. *The hospital of the future: Planning hospitals with limited evidence. A research and policy problem.* British Medical journal. Vol.319. pp.1361-63

- Egbu, C, O., Lee, C, C,. 2006. *The Development of a Methodology to Match the Clients Project requirements with the Knowledge of the Project Team in Refurbishment projects.* COBRA. RICS. Dauphine Universite, Paris. 2-3 September 2010

- Ekel, P. Pedrycz, W. Schinzinger, R. 1999. *Methods of Multi-Criteria Decision Making in Fuzzy Environment and their Applications.* Annual Conference of the North American Fuzzy Information Processing Society – NAFIPS. 10-12 June. New York. Pp. 625-629

- Ellingham, E and Fawcett, W. (2006) *New Generation Whole-Life Costing. Property and construction decision-making under uncertainty* Taylor & Francis. Abingdon. UK

- Elliot, S, R., 2005 *Sustainability: An Economic Perspective* Resources Conservation and Recycling 44. pp. 263-277

- Environmental Awareness Scheme for Employees [Online] Accessed: 10/07/13 Available from: http://www.epaw.co.uk/ease/nhstrial/ease/index2.html

- European Environment Agency (EEA. 2006) *Urban sprawl in Europe: The ignored challenge.* Accessed: 10/07/13 Available from: http://www.eea.europa.eu/pressroom/newsreleases/urban-sprawl-europes-ignored-environmental-challenge

- Environmental Management Systems [Online] Accessed: 10/07/13. Available from: http://scom.hud.ac.uk/scomjm4/mmport/susmod/Page11.htm

- European Commission: Environment [Online] *EMAS: The European Eco-Management and Audit Scheme.* Accessed: 10/07/13 Available from: http://ec.europa.eu/environment/emas/about/summary_en.htm

- Fayad, M, E., Johnson, R, E., Schmidt, D, C. (1999) *Building Application Frameworks*. Wiley. New York

- Fellows, R and Liu, A (1997) *Research Methods for Construction.* Blackwell Science Ltd. Oxford

- Fellows, R and Liu, A (2008) *Research Methods for Construction.* 3rd Edition. Wiley-Blackwell. Chichester

- Gatto, M. 1995. *Sustainability: Is it a well defined concept?* Ecological Applications Vol. 5 (4) pp. 1181-1183. The Ecological society of America (Letters to the editor)

- Gaydos LMD, Veney JE., 2002. The nature and etiology of disease. *World health systems: challenges and perspectives.* Chicago. Health Administration Press: p.3-24

- Gibb, A., Austin, S., Dainty, A., Davison, N and Pasquire, C. 2007. *Towards adaptable buildings: pre-configuration and re-configuration- two case studies.* Manubuild first international conference. 25 -26 April. 2007. Rotterdam

- Gibson, R, B. 2006. *Beyond the Pillars: Sustainability assessment as a framework for effective integration of social, economic, and ecological considerations in significant decision making.* Journal of Environmental Assessment Policy and Management. Vol 8. Issue 3. pp. 259-280

- Giebeler, M. Fisch, P. Krause, R., 2009 *Refurbishment Manual: Maintenance, Conversions, Extensions.* Birkhauser Verlag AG. Munich

- Glaser, B, G. (1978) *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory* Sociology Press. Mill Valley. California. USA

- Global Reporting Initiative (GRI), 2002a. *The Global Reporting Initiative: An Overview.* Global Reporting Initiative, Boston, USA.

- Global Reporting Initiative (GRI), 2002b. *Sustainability reporting guidelines2002 on Economic and Social Performance.* Boston, USA.

- Glossary of Climate Change [Online] Accessed10/07/13 . Available from: http://www.global-greenhouse-warming.com/glossary-climate-change.html

- Good Corporate Citizen Model [Online] Accessed: 10/07/13 Available from: http://www.corporatecitizen.nhs.uk/

- Gorard, S (2006) *Using Everyday Numbers Effectively in Research* Continuum Research Methods Series. London. UK

- Gray, D, E (2004) *Doing Research in the Real World* sage Publications. London

- Greenfield, T (2002) *Research Methods for Postgraduates* 2nd Edition. Arnold. London

- Greening, L, A., Bernow, S. 2004 *Design of Co-ordinated and Environmental Policies: Use of Multi-Criteria Decision Making.* Energy Policy 32 (6) pp. 721-735

- Hall, D and Hall, I (1998) *Practical Social Research: Project Work in the Community* Macmillan Press. London

- Hardcastle, C., Holmes, A., Nairn, C., 1997. *Requirements from Refurbished Office Space: the views of occupiers, planners, and developers.* RICS Cutting Edge Conference. University of West England. Bristol

- Health Facilities Scotland (2009) *A Sustainable Development Strategy for NHS Scotland.* NHS National Services Scotland. Version 1. April 2009

- Health Facilities Scotland (2010) *Property Appraisal Guidance for NHS Scotland: A risk based methodology for property appraisal* Property and capital Planning. Accessed: 10/07/13 Available from: http://www.pcpd.scot.nhs.uk/PDFs/PAGuide1110.pdf

- Health Facilities Scotland (2011) *Estates Asset Management. Property Appraisal Manual* [re: Property Appraisal Guidance Document for NHS Scotland] National Services Scotland. Version 1.0

- Health Facilities Scotland. NHS National Services Scotland. *A Sustainable Development Strategy for NHS Scotland.* 2009

- Healthy Lives, Healthy People [Online]: Consultation Response from the Sustainable Development Unit 20 Dec 2010. Dr David Pencheon. Accessed: 10/07/13 Available from: http://www.sdu.nhs.uk/documents/publications/consultations/Healthy%20Lives%20Healthy%20People%20response%20-%20NHS%20SDU.pdf

- Henry Gannt: Biography & History. [Online] Accessed: 10/07/13 Available from: http://www.gantt-chart.biz/henry-laurence-gantt/

- Hens, L. 1996 *The Rio Conference and Thereafter* Sustainable Development. Brussels. VUB Press.

- Hesan, Q, A. Yee-Koon, K. Chin-Meng, T. Poh-Seng, W., 2001 *Motivation for ISO 14001 certification: development of a predictive model* Omega: The International Journal of Management Science 29. pp. 525-542

- Hillman, K., 1998. *Restructuring Hospital Services.* Medical Journal of Australia, 169(5):239

- HM GOVERNMENT [Online]. 2011. *The Health and Social Care Bill 2010-2011* Accessed: 10/07/13. Available from: http://services.parliament.uk/bills/2010-11/healthandsocialcare.html

- HM Government, 2008., *Strategy for Sustainable Construction* Strategic Forum for Construction

- HM Treasury (2011) *The Green Book Appraisal and Evaluation in Central Government* HM Treasury. London. UK

- Holt, G, D. (1998) *A Guide to successful dissertation study for students of the built environment*. 2nd Edition. The Built Environment Research Unit. University of Wolverhampton

- How Green is the City. 2001. *Sustainability assessment and the Management of Urban Economics* ed. Devuyst, D. Hens, L. De Lannoy. W. Columbia Community Press. New York.
- http://www.statutelaw.gov.uk/legResults.aspx?LegType=All+Legislation&title=climate+change&Year=2008&searchEnacted=0&extentMatchOnly=0&confersPower=0&blanketAmendment=0&TYPE=QS&NavFrom=0&activeTextDocId=3539938&PageNumber=1&SortAlpha=0

- Institute of Environmental Management and Assessment [Online] *EMS Explained – 'the basics'* Accessed: 10/07/13. Available from: http://www.iema.net/ems/emsexplained

- Institute of Environmental Management and Assessment [Online] *Introducing EMAS* Accessed: 10/07/13. Available from: http://www.iema.net/ems/emas

- Intergovernmental Panel on Climate Change. (2001) Third Assessment Report. Accessed: 10/07/13. Available from: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

- International Standards Organisation. 2008. *The ISO Survey of ISO 9000 and ISO 14001 Certifications* 17th Cycle. ISO. Geneva.

- ISO 55000 (2012) *International Standard for Asset Management* Accessed: 10/07/13.. Available from: http://www.iso55000.info/

- ISO/DIS [Online] Accessed: 18/03/11. Available from:
- Kahlenborn, W., 2004 *The World Below ISO 14001* ISO/TC 207's 12th Plenary Meeting. Buenos Aires, Argentina.

- Kates, R. W., W. C. Clark, R. Corell, J. M. Hall, C. C. Jaeger, I. Lowe, J. J. McCarthy, H. J. Schellnhuber, B. Bolin, N. M. Dickson, S. Faucheux, G. C. Gallopin, A. Grubler, B. Huntley, J. Jager, N. S. Jodha , R. E. Kasperson, A. Mabogunje, P. Matson, H. Mooney, B.

Moore III, T. O'Riordan, and U. Svedlin. 2001. Sustainability science. *Science* **292**:641–642.

- Kerzner, H., 2001. *Project Management: A Systems Approach to Planning, Scheduling and Controlling.* New York. Wiley

- Kimitaka, N., 2009. *An empirical study of the initial adoption of ISO 14001 in Japanese manufacturing firms.* Ecological Economics Vol. 68 pp. 669-679

- Kirk, S,J and Dell'Isola, A (1995) Life Cycle Costing for Design Professionals. 2nd ed. Mcraw-Hill. New York. pp.102-103

- Kishk, M, E. 2001 *An Integrated Fuzzy approach to Whole Life Costing Based Decision Making.* PhD Thesis. The Scott Sutherland School of Architecture and the Built Environment. The Robert Gordon University.

- Kishk, M., Laing, R., Scott, J. and M. Edge (2008) R&D Project B(04)02: Developing an integrated system for the optimal selection of hospital finishes, Report to Department of Health
- Kolokotsa, D. Diakaki, C. Grigoroudis, E. Stavrakakis, G. Kalaitzakis, K. 2009. *Decision Support Methodologies on the Energy Efficiency and Energy Management in Buildings.* Advances in Building Energy Research. Vol 3. pp. 121-146

- Lam, P, T, I. Chan, E, H, W. Chau, C, K. Poon, C, S. Chun, K, P., 2011 *Environmental Management System vs Green Specifications: How do they compliment each other in the construction industry?* Journal of Environmental Management 92 (2011) pp. 788-795

- Lancker, E. Nijkamp, P. 2000. *A policy scenario analysis of sustainable agricultural development options: a case study for Nepal.* Impact Assessment. Project appraisal 18 (2) pp. 111-124

- *Leadership in Energy and Environmental Design (LEED)* US Green Building Council. Accessed: 10/07/13. Available at: http://new.usgbc.org/leed

- Liu, Y., Prasad, D., LI, J, Fu, Y., Liu, J. 2006. *Developing regionally specific environmental tools for China.* Building Research and Information. 34(4) pp. 372-386

- Loken, E. 2005. *Use of Multicriteria Decision Analysis Methods for Energy Planning Problems.* Renewable and Sustainable Energy Reviews. 11 (2007) pp. 1584-1595

- Lombardi, P, L., 2001. *Responsibilities Towards the Coming Generations: Forming a New Creed.* Urban Design Studies No. 7 pp. 89 -102

- Loo, V, G., Bertrand, C., Dixon, C., Vitye, D., DeSalis, B., McLean, A,P. (1996) *Control of construction-associated nosocomial aspergillosis in an antiquated hematology unit* Infection Control and Hospital Epidemiology, Vol 17, No. 6 360-364

- Loose, J. (1993) *A Historical Introduction to the Philosophy of Science.* 3rd Edition. Opus. Oxford

- Lucas, J., Tanyel, B., Walid, T (2013) *A Pilot Model for a Proof of Concept Healthcare Facility Information Management Prototype* Journal of Information Technology in Construction (ITcon) Vol. 18, pp. 76-98

- Lutz, B., Jin, J., Rinaldi, M, G., Wickes, B, L., Huycke, M, M. (2003) *Outbreak of invasive Aspergillus infection in surgical patients, associated with a contaminated air-handling system* Clinical Infectious Diseases. Vol.37, No. 6, 786-793

- Macdonald, J, P., 2005 *Strategic Sustainable Development using the ISO 14001 Standard* Journal of Cleaner Production 13 pp. 631-643

- Manewa, A., Pasquire, C., Gibb, A and Schmidt 3rd, R. 2010. *A paradigm shift towards whole life analysis in adaptable buildings.* Loughborough Institutional Repository

- Mann, Michael E. (2012) The hockey stick and the climate wars: dispatches from the front lines. Columbia University Press.

- Mansfield, J, R., 2001. *What's in a Name? Complexities in the Definition of Refurbishment.* Journal of Property Management. Vol.20 No. 1, 2002, pp. 22-30

- Mansfield, J., 2009. *Sustainable Refurbishment: Policy Direction and Support in the UK.* Structural Survey. Vol.27. No.2 pp. 148-161

- Markus, A, M., 1979. *Building Conversion and Rehabilitation: Designing for Change in Building Use.* Newnes-Butterworth. London

- Markus T, A. (1979) Building conversion and rehabilitation: Designing for change in building use Newnes-Butterworth. London

- Maslow, A (1966) *Psychology of Science* Harper and Row. New York

- Maxwell, J (2005) *Qualitative Research Design: An Interactive Approach* 2nd edition. Sage Publications. London.

- McBurney, D, H (1998) *Research Methods* Brookes/Cole. 4th Ed. Pacific Grove. CA

- McEachern, W, A, M. 2000 *Macro-Economics: A Contemporary Introduction*. South Western College Press. Cincinnati. USA

- Mcguire, B (2012) *Waking the Giant* Oxford University Press. Oxford pp. 19

- McKee and Healy., 2002. Pressures for Change (in) Hospitals in a changing Europe. Buckingham. Open University Press

- Melnyk, S, A. Sroufe, R, P. Calantone, R., 2003 *Assessing the impact of environmental management systems on corporate and environmental performance* Journal of Operations Management 21 pp. 329-351

- Mendoza, G, A., Martins, H. 2006 *Multi-Criteria Decision Analysis in Natural Resource Management: A Critical Review of Methods and New Modelling Paradigms* Forest Ecology and Management 230 elsevire Publications. pp. 1-22

- Miles, M, P. Russel, G, P., 1997 *ISO 14001 total quality environmental management: The integration of environmental marketing, total quality management, and corporate environmental policy.* Journal of Quality Management 2 (1) pp. 151-168

- Miller, R, L. Swensson, E, S., 1995. *New Directions in Healthcare and Hospital Facility Design.* Hong-Kong. McGraw-Hill

- Miller, T, S., 1997. *The Birth of the Hospital in the Byzantine Empire.* Baltimore, MD: Johns Hopkins University Press

- Mitchell, J, S and Amadi-Echendu, J, E. (2007) *Physical Asset Management Handbook*. Clarion Technical Publications

- Morrisey, J.m Iyer-Raniga, U., McLaughlin, P., Mills, A (2011) *A Strategic Project Appraisal Framework for Ecologically Sustainable Urban Infrastructure* Environmental Impact assessment Review 33 pp. 55-65

- National Services Scotland (2007) *HAI-SCRIBE: Healthcare associated Infection System for Controlling Risk in the Built Environment* Implementation Strategy. Health Facilities Scotland. Version 1

- Ness, B. Urbel-Piirsalu, E. Anderberg, S. Olsson, L. 2006. *Categorising tools for sustainability assessment*. Journal of Ecological Economics 60. pp. 498-508
- NHS Executive (1994) Capital Investment Manual. HMSO. London. Accessed: 10/07/13. Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4119896

- NHS Executive. (1994) *Capital Investment Manual. Business Case Guide*. HMSO. London

- NHS Executive. (1994) *Capital Investment Manual. Overview*. HMSO. London. Section 3.1.1. pp. 8

- NHS Grampian (2010) *NHS Grampians Health Plan 2010 to 2013 (Healthfit)* Accessed: 10/07/13. Available from: http://www.nhsgrampian.org/nhsgrampian/files/GHP2010-13.pdf

- NHS Grampian (2012) *ARI Inpatient Reconfiguration Report* Acute Sector Reconfiguration and Service Planning Group. Main Report

- NHS Grampian (2012) *Initial Agreement. Health Campus Programme.* Aberdeen Royal Infirmary Inpatient Services. Backlog Maintenance in Existing Inpatient Areas (Phase 2 and East End Buildings)

- NHS Grampian (2012) *Property and Asset Management Plan* Draft Version 9. May 2012

- NHS Grampian (2012) *Property and Asset Management Plan: 2012 to 2021* Draft version 9.

- NHS Jobs [online] Accessed: 10/07/13.. Available from: http://www.jobs.nhs.uk/about_nhs.html

- NHS Scotland (2011) *Estates Asset Management. Property Appraisal Manual* Health Facilities Scotland. Property and Capital Planning. Version 1.0

- *NHS Scotland EstatesManager*. 3i Studio. Accessed: 10/07/13. Available at: http://www.3istudio.com/

- NHS Sustainable Development Unit. 2009. Saving Carbon, Improving Health: NHS Carbon Reduction Strategy. Cambridge. NHS SDU

- O'Doherty, J., 1998 *Implementing an Environmental Management System in a Irradiation Facility* Radiat. Phys. Chem. Vol. 52. Nos 1-6 pp. 519-522

- Oren, I., Haddad, N., Finkelstein, R., Rowe, J, M. (2001) *Interaction of project processes and phases in project scheduling using BIM for a/e/c/fm integration* Construction Research Congress 2010. Innovation for re-shaping construction practices. 939-948

- Organisation for Economic Co-Operation and Development (OECD) 2002a. *Update of the OECD composite leading indicators.* Short-term economics statistics division. Statistics Directorate/OECD.

- Organisation for Economic Co-operation and Development (OECD) 2002b. *OECD Guidelines for Multinational Enterprises.* Annual Report 2002.

- OECD (2006) *Adaptation to Climate Change: Key Terms* Environment Directorate. International Energy Agency. Paris

- Oven, K, J., Curtis, S, E., Reaney, S., Riva, M., Stewart, M, G., Ohlemuller, R., Dunn, C, E., Nodwell, S., Dominelli, L., Holden, R. (2012) *Climate Change and Health and Social Care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England.* Journal of applied Geography 33 pp. 16-24

- Our Common Future (The Brundtland Report) 1987 *Report of the 1987 World Commission on Environment and Development*. Oxford University Press

- Oxford English Dictionary (Paperback). 2010. 2nd edition. Oxford University Press. Oxford. Pp. 765

- Paperback Oxford English Dictionary. 2010. Second edition. Soanes, C (ed) Oxford University Press. Oxford pp.364

- Parkin, S., 2000 *Sustainable Development: The Concept and the Practical Challenge.* Proceedings of the Institute of Civil Engineers. Civil Engineering No. 138 (Special issue) pp. 3 – 8

- Poon, C, S. Yu, T, W. Jaillon, L., 2004 *reducing Building Waste at Construction Sites in Hong Kong* Construction Management and Economics 22, pp. 461-470
- Porter, M, E., 1991 *Americas Greening Strategy* Scientific American 264 (4) pp. 168

- Project Management Institute., 1996. *A guide to the Project Management Body of Knowledge* (PMBOK)

- QAA (2008) *The framework for higher education qualifications in England, Wales and Northern Ireland* The Quality Assurance Agency for Higher Education. Mansfield

- Quah, L, K., 1988. An Evaluation of the Risks in Estimating and Tendering for Refurbishment Work. Department of Building. Herriot-Watt University, Edinburgh

- Raupach etal. 2007 [Online] *Global and Regional Drivers of accelerating CO2 Emissions.* Accessed: 10/07/13.. Available from: http://www.pnas.org/content/104/24/10288.full.pdf

- Rayers, J., Mansfield, J., 2001 *The Assessment of Risk in Conservation Refurbishment Projects.* Journal of Structural Surveyors. 19 (5): pp.238-244

- Rechel et al. 2009. Investing in Hospitals of the Future. European Health Property Network. Observatory Studies Series No: 16 United Kingdom

- Reed, R., Bilos, A., WIlkinson, S., Shulte, K-W. 2009. *International Comparison of Sustainable Rating Tools.* JOSRE Vol. 1. No. 1

- Research Methods Knowledge Base [online] *Deduction and Induction* Accessed: 10/07/13. Available from: http://www.socialresearchmethods.net/kb/dedind.php
- Riley, M. Cotgrave, A., 2005. *The Technology of refurbishment and Maintenance*. Palgrave Macmillan. Basingstoke

- Robson, C (2011) *Real World Research* 3rd Ed. John Wiley & Sons. Chichester. UK

- Rosnow, R, L., Rosenthal, R. (1989) *Statistical Procedures and the Justification of Knowledge in Psychological Science* American Psychologist. Vol. 44 No. 10 pp. 1276-1284

- Scotsman Online News. Rising budget but NHS will still have to find more savings, says watchdog., 2010 [online] Accessed. 10/07/13. Available from: http://news.scotsman.com/health/Rising-budget-but-NHS-will.6662025.jp

- Scott Cato. M., 2009 *Green Economics.* Earthscan Books. London. pp. 36-37

- Scottish Capital Investment Manual.(2010) The Scottish Government. Accessed: 10/07/13. Available at http://www.scim.scot.nhs.uk/Manuals.htm

- Scripps Institution of Oceanography (online) *Scripps News* Accessed: 10/07/13. Available from: http://scrippsnews.ucsd.edu/Releases/?releaseID=687

- Selih, J. 2008. *Sustainable Management of Building stock Refurbishment by using MCDM*. Department of Civil and Geodetic engineering. University of Ljubljana. Slovenia

- Sheth et al 2008. *Reviewing the sustainability of existing healthcare facilities.* Department of Civil & Building Engineering. Loughborough University

- Sheth, A, Z. (2011) *A Refurbishment Framework with an Emphasis on Energy Consumption of Existing Healthcare Facilities* PhD Thesis. Loughborough University.

- Short, C, A. Lomas, K, J. Giridharan, R. Fair, A, J. (2012) Building resilience to overheating into 1960's UK hospital buildings within the constraint of the national carbon reduction target: Adaptive strategies Building and Environment 55 pp. 73-95

- Singh, R, K. Murty, H. R. Gupta, S, K. Dikshit, A, K. 2008. *An overview of sustainability assessment methodologies*. Ecological Indicators 9. pp. 189-212

- Stern, N. (2006) *The Economics of Climate Change. The Stern Review* Cabinet Office – HM Treasury. Cambridge University Press. Cambridge.

- Strategic Health Asset Planning and Evaluation. NHS. Accessed: 10/07/13.. Available from: http://shape.dh.gov.uk/

- Strauss, A, L. and Corbin, J. (1998) *Basics of Qualitative Research* 2nd ed. Sage Publications. Thousand Oaks. CA.

- Sumner, P. Thorpe, B., 2004 *Quality Management in Construction* CITB

- Construction Skills. Gower Publishing Limited. Aldershot

- Sustainable Development Commission [Online] *What is Sustainable Development* Accessed: 10/07/13. Available from: http://www.sd-commission.org.uk/pages/what-is-sustainable-development.html

- Sutrisna, M (2009) *Research methodology in doctoral research: Understanding the meaning of conducting qualitative research.* Working paper presented in ARCOM doctoral workshop. Liverpool John Moores University. 12th May 2009

- Sutrisna, M (2012) Notes taken from a Doctoral workshop discussion. Proceedings of the Royal Institute of Chartered Surveyors (COBRA) conference. 14th September 2012. Monte Carlo Resort. Las Vegas

- The Carbon Trust [Online] Accessed 10/07/13.:. Available from: http://www.carbontrust.co.uk/Pages/Default.aspx

- The Green Book. HM Treasury. Appraisal and Evaluation in Central Government. Accessed: 10/07/13. Available at http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

- The Scottish Government - a (2010) *Scottish Capital Investment Manual* Business Case Guide

- The Scottish Government (2009) *Scottish Capital Investment Manual. PPP Guide: Section 1. Preparing for PPP Procurement.* pp: 03

- The Scottish Government (2010) *CEL 35. A Policy for Property and Asset Management in NHS Scotland* Scottish Government Health Finance Directorate Capital Planning and Asset Management

- The Scottish Government [Online] *The Built Environment Sector Action Plan* Accessed: 10/07/13. Available from http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/adaptation/AdaptationFramework/SAP/BuiltEnvironment/PDF

- The Scottish Government (2010) *Scottish Capital Investment Manual. Business Case Guide*. Accessed: 10/07/13. Available at http://www.scim.scot.nhs.uk/Manuals.htm

- The Scottish Government (2010) *Scottish Capital Investment Manual* Accessed: 10/07/13. Available from: http://www.scim.scot.nhs.uk/PDFs/Manuals/MCP/MCP_1.pdf

- The Scottish Government (2011) Baxter, M. *Healthcare Planner Workshop: The Strategic Context* Accessed: 10/07/13. Available from: https://docs.google.com/viewer?a=v&q=cache:AXWTPlds7P4J:www.hfs.scot.nhs.uk/downloads/1319446836-Healthcare%252Bplanner%252Bevent%252B-%252B26%252BAugust%252B2011%252B-%252BM%252BBaxter%252Bpresentation.pdf+healthcare+planner+workshop:+the+strategic+context+%22mike+baxter%22&hl=en&gl=uk&pid=bl&srcid=ADGEEShVgbigKFlUnWaIOraqHKMv-qGvWAxgsrzO9ICFEdRWDzIQo_G8-UGu5vG7MNIsDBw786_cSrnfMrgT481IwfTiY96wyK-PVw6jtOAMXGsx0IudO6c5jKIZbvMnYIb2sgHa3oo7&sig=AHIEtbSnXD1wSOGV6RislntNqnAT2eeLlQ&safe=active

- The Scottish Government (2012) *Annual State of NHS Scotland assets and Facilities Report 2012* Draft version 18.
- The Scottish Government [Online] 2011. *Climate Change (Scotland) Act 2009.* Accessed: 10/07/13.. Available from: http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/climatechangeact

- The Scottish Government [online] *NHS Scotland*: *Approvals process and delegated limits.* Accessed: 10/07/13. Available at: http://www.scim.scot.nhs.uk/Approvals/Delegated.htm

- The Scottish Government. (2010) *The Healthcare Quality Strategy for NHS Scotland* Accessed: 10/07/13. Available from: http://www.scotland.gov.uk/Resource/Doc/311667/0098354.pdf

- Thomas, G (2009) *How to do your research project* Sage Publications. London

- Todd, J, A., Crawley, D., Geissler, S., Lindsey, G. 2001. *Comparative assessment of environmental performance tools and the role of the green building challenge.* Building Research and Information. 29(5) pp. 324-335

- Triantaphllou, E. 2000. *Applied Optimisation. Multi-criteria Decision Making methods: A Comparative Study.* Kluwer Academic Press. Dordrecht. The Netherlands
- Trusty, J.A. 2000 *Introducing an assessment tool classification system.* Royal Architectural Institute of Canada Advanced Building Newsletter. No. 25. 18-19

- UKCIP (United Kingdom Climate Impacts Programme) (2005) *Measuring Progress: Preparing for climate change through UKCIP* Accessed: 10/07/13. Available from: http://www.ukcip.org.uk/resources/#M

- UNCED (1992) *Report of the United Nations on Environment and Development* Annex 1. Rio Declaration on Environment and Development. Rio De-Janerio. 3-14th June 1992.

- United Nations Development Programme (UNDP) 2005. *UNDP Annual Report 2005: A Time for Bold Ambition* Accessed: 10/07/13. Available from: http://www.undp.org/content/undp/en/home/librarypage/corporate/undp_in_action_2005.html

- United Nations: General Assembly 1992. *Report of the United Nations on Environment and Development.* Annex 1. Rio Declaration on Environment and Development. Rio De-Janeiro. 3-14 June 1992.

- VijayaVenakaRaman, S. Iniyan, S. Goic, R. (2011) *A Review of Climate Change, Mitigation and Adaptation* Journal of Renewable and Sustainable Energy Reviews 16. pp 878-897

- Walkenbach, J (2010) *Microsoft® Excel® 2010* Bible. Wiley Publishing. Indianapolis

- Wilson, G and Kishk, M. (2011) *Meeting Sustainability Requirements for the Refurbishment of Hospitals* Proceedings of the ARCOM Conference. Bristol. Sept 3rd to 5th 2011.

- Wilson, G. 2011 *A Review of Environmental Management Systems* A non-peer reviewed working paper undertaken as part of the literature review of a wider PhD study. Robert Gordon University. Aberdeen.

- Wilson, G., Kishk, M., Laing, R. (2012) *A Conceptual Decision Support Model for Sustainable Hospital Refurbishment* Proceedings of the COBRA conference. Royal Institute of Chartered Surveyors. Las Vegas. Nevada. Sept 13th – 15th . 2012

- Woodhouse, J. (2007) *Asset Management: Joining up the jigsaw puzzle – PAS 55 integrated management of assets* Accessed: 10/07/13. Available from: http://www.maintenanceonline.co.uk/maintenanceonline/content_images/p12%20Asset%20Management%20PAS55.pdf

- World Business Council for Sustainable Development (WBCSD) 1997. *Signals for Change: Business Progress Towards Sustainable Development.* Geneva. Switzerland.

- World Wide Fund for Nature. 2006. *The Living Planet Report.* The zoological society of London and the Global Footprint Network.

- Zharghami, M and Szidarovszky, F (2011) multi-criteria analysis: applications to Water and Environment Management. Springer. Heidleberg

- Zavadskas, E, K., Kaklauskas, A., Tupenaite, L., Mickaityte, A. (2008) Decision Making Model for Sustainable Buildings Refurbishment. Energy Efficiency Aspect.*7th International Conference in Environmental Engineering May 22-23.* Vilnius Gediminas Technical University. Lithuania
- Zavrl, M, S. Zarnic, R. Selih, J. (2009) Multicriterial Sustainability Assessment of Residential Buildings.Technical and Economic Development of Economy. Baltic Journal on Sustainability 15(4): 612-630
- Zharghami, M and Szidarovszky, F (2011) *multi-criteria analysis: applications to Water and Environment Management.* Springer. Heidleberg
- Zimmerman, H, J. 1996 *Fuzzy Set Theory and its Applications* Kluwer Academic publishers. 3rd revised edition. Boston. MA. USA
- Zimmerman, K, O (2011) *Resilient Cities: Cities and Adaptation to Climate Change* Proceedings of the Global Forum 2010. Springer. Dordrecht pp. v

8TH October 2011

Dear………..

Please excuse the 'cold call' nature of this invitation, but wondered if I could request 10 minutes of your time to complete the questionnaire (link below) which forms part of my PhD research project?

I am developing an integrated decision making model to facilitate and assist the business case process, in regards especially to demonstrating 'Value for Money'.

The questionnaire is **'non-random'**, and you have been specifically identified as a practitioner/expert in your field. To this end, your input and participation is of immense value to the research.

The survey is completely anonymous, and I fully understand how busy peoples diaries are. However, if you could participate, it would be very much appreciated and the results of the questionnaire/research, will of course be made available to you if you wish.

https://www.surveymonkey.com/s/GM8K2MW

Please don't hesitate to contact me if you wish to discuss any aspect of the survey or the research.

Thank you for your time in considering this request.

With best regards

Grant Wilson

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3rd November 2011

Dear ……..

I am shortly closing the survey site to collect and analyse the excellent data so far received in the attached survey.

As a polite reminder (and I do apologise in advance if you've already completed), I have again forwarded the link.

https://www.surveymonkey.com/s/GM8K2MW

The results will be available once analysed and published, so please feel free request a copy (February 2013)

Again…many thanks indeed for your time and for the excellent feedback.

With very best regards
Grant

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Sustainable Hospital Refurbishment PhD

Introduction

Dear Participant

Thank you for taking the time to participate in this brief 20 question survey. The data collected will inform an ongoing PhD research programme which seeks to develop an Integrated Decision Support System, focusing on the sustainable refurbishment of hospitals and healthcare facilities. You have been invited as an identified expert and practitioner in your field, and as such your responses will be of immense value. The questionnaire is anonymous, yet the anonymised data will be made available upon request, and as an integral part of the research report.

The survey closing date is the 30th November 2012, and a polite reminder will be offered 2 weeks prior to this date. Again; thank you very much for your participation, and please do not hesitate to contact me directly should you have any queries or wish to discuss the research area.

With kind regards
Grant Wilson

g.wilson2@rgu.ac.uk

Sustainable Hospital Refurbishment PhD

Section 1: Participant Information

Targeted at your specific discipline, this section seeks to measure the professional demographic of the survey participants.

1. On the understanding that there may be instances of multiple roles carried out by an individual, which of the following groupings best describes your 'current' core discipline or affiliation?

- NHS Management (Estates and facilities)
- NHS Management (Asset)
- NHS Management (General)
- Principal Supply Chain Partner (Architect)
- Principal Supply Chain Partner (Engineer)
- Principal Supply Chain Partner (Contractor)

Other (please specify)

2. Within your stated discipline given in Question 1: please indicate your level of experience in years .

- 0 - 5
- 5 - 10
- 10 +

3. Relevant to your professional discipline, please indicate your level of experience in regards to the following healthcare facilities.

	No experience	Little experience	Reasonable experience	Good experience	High level of experience
GP Surgery					
Health Centre/Clinic					
Community Hospital (Mental Health/Geriatric etc)					
Standard Acute Hospital (In-patient)					
Specialist Acute Hospital (Diagnostics and specialist services)					

Sustainable Hospital Refurbishment PhD

4. Following on from your response in Question 3: please judge your level of experience specifically related to the activity of refurbishment (this includes significant maintenance projects relating to main structural elements, services etc)

	No experience	Little experience	Reasonable experience	Good experience	High level of experience
GP Surgery	○	○	○	○	○
Health Centre/Clinic	○	○	○	○	○
Community Hospital (Mental Health/Geriatric etc)	○	○	○	○	○
Standard Acute Hospital (In-patient)	○	○	○	○	○
Specialist Acute (Diagnostics and specialist services)	○	○	○	○	○

5. Related to your professional discipline: please indicate what you consider your awareness on issues of sustainability to be (in the context of the social, environmental, and economic dimensions)

- ○ None or very poor understanding
- ○ Basic understanding
- ○ Average working knowledge
- ○ Good understanding
- ○ Excellent understanding

Sustainable Hospital Refurbishment PhD

Section 2: Sustainable Refurbishment - Technical Issues

This section seeks to collect a more detailed understanding of the familiarity and knowledge base on the more sustainability focused issues relating to healthcare refurbishment projects, including documentation and procedural issues.

6. Please consider the sustainability issues shown, and rank them in perceived order of priority. (it is accepted that there may be conflicts of priority and difficulties in ranking, however, please complete to the best of of your judgement)...'Drag and drop' the issues into place

- Community
- Design Quality
- Energy and Carbon Emissions
- Flood Risk & Urban Drainage
- Future Proofing
- Health and Well-Being
- Land Use & Ecology
- Local Environment
- Materials
- Pollution
- Transport
- Waste
- Water Use

Sustainable Hospital Refurbishment PhD

7. Please indicate your level of familiarity with the following documents.

	None	Very little	Moderate	Good	Detailed
Building Regulations / Technical Standards					
Codes of Practice / British Standards					
Scottish Health Technical Memorandums (SHTM)					
Scottish Health Building Notes (SHBN)					
Scottish Health Planning Notes (SHPN)					
Clinical Output Specifications					

8. Please indicate your level of familiarity with the following tools and systems.

	None	Very little	Moderate	Good	Detailed
Activity Data Base (Online room data sheets/layouts etc)					
Building Research Establishment Environmental Assessment Method (BREEAM)					
Leadership in Energy Management & Environmental Design (LEED)					
Achieving Excellence Design Evaluation Toolkit (AEDET)					
ISO 14001 Environmental Management Systems					
ISO 16001 Energy Management Systems					
Green Guide to Specification					
Healthcare Associated Infection System for Controlling Risk in the Built Environment (HAI-SCRIBE)					

Sustainable Hospital Refurbishment PhD

9. The following is a set of statements about attitudes to the BREEAM assessment as a tool for use in healthcare refurbishment projects. Please select appropriate box.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
BREEAM is an appropriate tool for hospital refurbishment projects					
BREEAM ensures that the project pursues best 'Value for Money'					
BREEAM is a good reference document for the Client and/or Design Team (Architect, Engineer, Contractor)					
BREEAM is generally well understood by the Client (NHS)					
BREEAM is generally well understood by the Design Team (Architect, Engineer, Contractor)					
Given the choice; I would always use BREEAM for hospital refurbishment projects					

10. Are there any other assessment or monitoring tools, or sustainability issues relating to healthcare which you feel should have been included within this section of the questionnaire? Please state:

Sustainable Hospital Refurbishment PhD

Section 3: Planning, Procurement, and Decision Making

This final section, seeks to measure the opinions and levels of familiarity, with the wider management processes, guidance documents, and tools of the asset/estates/business case management processes.

11. Working on the assumption, that the NHS as the Client, and the Design Team/Principal Supply Chain Partner (PSCP) are framing their investment objectives and decisions within the NHS Scotland strategy (of 'Person Centred, Safe, and Effective'.) How relevant in element/material/component specification terms, do you consider the patients/general public to be in the 'actual decision making processes' against each of the following issues? ('1' being of no relevance, and '10' being of critical relevance)

	'1' No relevance	2	3	4	5	6	7	8	9	'10' Critical relevance
Community	○	○	○	○	○	○	○	○	○	○
Local Environment	○	○	○	○	○	○	○	○	○	○
Design Quality	○	○	○	○	○	○	○	○	○	○
Flood Risk & Urban Drainage	○	○	○	○	○	○	○	○	○	○
Future Proofing	○	○	○	○	○	○	○	○	○	○
Health & Well-Being	○	○	○	○	○	○	○	○	○	○
Energy and Carbon Emissions	○	○	○	○	○	○	○	○	○	○
Transport	○	○	○	○	○	○	○	○	○	○
Water Use	○	○	○	○	○	○	○	○	○	○
Materials	○	○	○	○	○	○	○	○	○	○
Waste	○	○	○	○	○	○	○	○	○	○
Land Use & Ecology	○	○	○	○	○	○	○	○	○	○
Pollution	○	○	○	○	○	○	○	○	○	○

12. What is your level of understanding of the 'Scottish Capital Investment Manual'? (SCIM)

○ None

○ Poor

○ Reasonable

○ Good

○ Excellent

Sustainable Hospital Refurbishment PhD

13. What is your level of understanding of the 'Scottish Futures Trust (SFT) - Key Stage Review' process?

- None
- Poor
- Reasonable
- Good
- Excellent

14. Are you familiar with the 'Property Appraisal Guidance for NHS Scotland' document?

- Yes
- No

15. Are you familiar with the 'Property and Asset Management Strategy' (PAMS) document?

- Yes (proceed to question 16)
- No (go to question 17)

16. In your experience and/or opinion; are the findings of the 'Property Asset Register' or PAMS document, discussed as key factors in the initial appraisal or outline design phase of a potential refurbishment project?

- Never
- Not very often
- Sometimes
- Mostly
- Always
- Unsure

17. Have you ever participated in, or facilitated, a process that has involved 'Multi-Criteria Decision Modelling' (MCDM) techniques?

- Yes (proceed to question 18)
- No (go to question 19)
- Don't know (go to question 19)

18. If you answered 'Yes' to question 17; please (to the best of your recollection) state the type of MCDM model/process used, and the purpose for its use.

Type of MCDM used

Purpose of use

Sustainable Hospital Refurbishment PhD

19. What is your level of familiarity with each of the following software platforms?

	None	Poor	Reasonable	Good	Excellent
MS Access	○	○	○	○	○
Visual Basic	○	○	○	○	○
MS Excel	○	○	○	○	○

20. In the context of healthcare refurbishment; please provide a brief statement on what you consider the definition of 'Value for Money' to be.

Sustainable Hospital Refurbishment PhD

Survey complete. Thank you

Thank you very much for taking the time to participate in this questionnaire. The information you have provided will be of great interest to the research and the models development, but also hopefully to you as professionals and practitioners in the field.

It is re-emphasised that this is an anonymous survey, however, the results will be made available to you once the survey date has closed on 30th November 2012.

Again; should you wish to discuss any aspect whatsoever of the survey or the wider research, please contact me at the e-mail address below, and I shall respond as soon as possible.

With very best regards
Grant Wilson

g.wilson2@rgu.ac.uk

Sustainable Hospital Refurbishment PhD SurveyMonkey

Within your stated discipline given in Question 1: please indicate your level of experience in years .

	Response Percent	Response Count
0 - 5	8.7%	9
5 - 10	24.0%	25
10 +	67.3%	70
	answered question	104
	skipped question	1

Sustainable Hospital Refurbishment PhD

SurveyMonkey

On the understanding that there may be instances of multiple roles carried out by an individual, which of the following groupings best describes your 'current' core discipline or affiliation?

	Response Percent	Response Count
NHS Management (Estates and facilities)	40.0%	38
NHS Management (Asset)	4.2%	4
NHS Management (General)	5.3%	5
Principal Supply Chain Partner (Architect)	11.6%	11
Principal Supply Chain Partner (Engineer)	7.4%	7
Principal Supply Chain Partner (Contractor)	31.6%	30
Other (please specify)		12
answered question		95
skipped question		10

Sustainable Hospital Refurbishment PhD SurveyMonkey

Relevant to your professional discipline, please indicate your level of experience in regards to the following healthcare facilities.

	No experience	Little experience	Reasonable experience	Good experience	High level of experience	Response Count
GP Surgery	22.7% (22)	14.4% (14)	13.4% (13)	25.8% (25)	23.7% (23)	97
Health Centre/Clinic	7.9% (8)	13.9% (14)	20.8% (21)	29.7% (30)	27.7% (28)	101
Community Hospital (Mental Health/Geriatric etc)	10.1% (10)	9.1% (9)	15.2% (15)	33.3% (33)	32.3% (32)	99
Standard Acute Hospital (In-patient)	5.0% (5)	7.9% (8)	8.9% (9)	27.7% (28)	50.5% (51)	101
Specialist Acute Hospital (Diagnostics and specialist services)	7.0% (7)	13.0% (13)	17.0% (17)	23.0% (23)	40.0% (40)	100
					answered question	103
					skipped question	2

Following on from your response in Question 3: please judge your level of experience specifically related to the activity of refurbishment (this includes significant maintenance projects relating to main structural elements, services etc)

	No experience	Little experience	Reasonable experience	Good experience	High level of experience	Response Count
GP Surgery	31.6% (31)	18.4% (18)	13.3% (13)	24.5% (24)	12.2% (12)	98
Health Centre/Clinic	22.0% (22)	19.0% (19)	13.0% (13)	27.0% (27)	19.0% (19)	100
Community Hospital (Mental Health/Geriatric etc)	17.8% (18)	15.8% (16)	15.8% (16)	31.7% (32)	18.8% (19)	101
Standard Acute Hospital (in-patient)	10.1% (10)	13.1% (13)	12.1% (12)	31.3% (31)	33.3% (33)	99
Specialist Acute (Diagnostics and specialist services)	10.1% (10)	20.2% (20)	19.2% (19)	22.2% (22)	28.3% (28)	99
					answered question	103
					skipped question	2

Related to your professional discipline: please indicate what you consider your awareness on issues of sustainability to be (in the context of the social, environmental, and economic dimensions)

	Response Percent	Response Count
None or very poor understanding	1.0%	1
Basic understanding	4.9%	5
Average working knowledge	22.3%	23
Good understanding	56.3%	58
Excellent understanding	15.5%	16
	answered question	103
	skipped question	2

Please consider the sustainability issues shown, and rank them in perceived order of priority. (it is accepted that there may be conflicts of priority and difficulties in ranking, however, please complete to the best of of your judgement)...'Drag and drop' the issues into place

	1	2	3	4	5	6	7	8	9	10	11	12	13	Rating Average	Response Count
Community	10.8% (10)	12.9% (12)	7.5% (7)	**14.0% (13)**	10.8% (10)	9.7% (9)	4.3% (4)	7.5% (7)	6.5% (6)	3.2% (3)	4.3% (4)	1.1% (1)	7.5% (7)	5.66	93
Local Environment	2.2% (2)	5.4% (5)	8.6% (8)	10.8% (10)	6.5% (6)	7.5% (7)	10.8% (10)	**14.0% (13)**	**14.0% (13)**	5.4% (5)	5.4% (5)	7.5% (7)	2.2% (2)	7.03	93
Design Quality	**25.8% (24)**	16.1% (15)	9.7% (9)	10.8% (10)	6.5% (6)	10.8% (10)	4.3% (4)	3.2% (3)	6.5% (6)	3.2% (3)	1.1% (1)	0.0% (0)	2.2% (2)	4.13	93
Flood Risk & Urban Drainage	0.0% (0)	5.4% (5)	3.2% (3)	6.5% (6)	4.3% (4)	4.3% (4)	12.9% (12)	7.5% (7)	12.9% (12)	**16.1% (15)**	11.8% (11)	5.4% (5)	9.7% (9)	8.42	93
Future Proofing	9.7% (9)	6.5% (6)	10.8% (10)	7.5% (7)	10.8% (10)	5.4% (5)	**11.8% (11)**	6.5% (6)	7.5% (7)	5.4% (5)	4.3% (4)	6.5% (6)	7.5% (7)	6.49	93
Health and Well-Being	**22.6% (21)**	8.6% (8)	12.9% (12)	9.7% (9)	7.5% (7)	9.7% (9)	5.4% (5)	5.4% (5)	5.4% (5)	4.3% (4)	4.3% (4)	2.2% (2)	2.2% (2)	4.86	93
Energy and Carbon Emissions	22.6% (21)	**24.7% (23)**	8.6% (8)	10.8% (10)	9.7% (9)	5.4% (5)	7.5% (7)	5.4% (5)	1.1% (1)	1.1% (1)	2.2% (2)	1.1% (1)	0.0% (0)	3.74	93
Transport	2.2% (2)	1.1% (1)	4.3% (4)	3.2% (3)	7.5% (7)	8.6% (8)	7.5% (7)	11.8% (11)	4.3% (4)	10.8% (10)	**15.1% (14)**	**15.1% (14)**	8.6% (8)	8.71	93
Water Use	0.0% (0)	1.1% (1)	0.0% (0)	9.7% (9)	8.6% (8)	7.5% (7)	5.4% (5)	12.9% (12)	9.7% (9)	5.4% (5)	6.5% (6)	7.5% (7)	**25.8% (24)**	9.08	93
Materials	1.1% (1)	7.5% (7)	8.6% (8)	4.3% (4)	6.5% (6)	11.8% (11)	7.5% (7)	3.2% (3)	9.7% (9)	**19.4% (18)**	8.6% (8)	7.5% (7)	4.3% (4)	7.62	93
Waste	2.2% (2)	2.2% (2)	11.8% (11)	4.3% (4)	8.6% (8)	8.6% (8)	11.8% (11)	4.3% (4)	9.7% (9)	5.4% (5)	7.5% (7)	**17.2% (16)**	6.5% (6)	7.85	93
Land Use & Ecology	0.0% (0)	3.2% (3)	4.3% (4)	3.2% (3)	2.2% (2)	5.4% (5)	7.5% (7)	10.8% (10)	8.6% (8)	8.6% (8)	15.1% (14)	**23.7% (22)**	7.5% (7)	9.25	93
Pollution	1.1% (1)	5.4% (5)	9.7% (9)	5.4% (5)	10.8% (10)	5.4% (5)	3.2% (3)	7.5% (7)	4.3% (4)	11.8% (11)	14.0% (13)	5.4% (5)	**16.1% (15)**	8.16	93
														answered question	**93**
														skipped question	**12**

Sustainable Hospital Refurbishment PhD

Please indicate your level of familiarity with the following documents.

	None	Very little	Moderate	Good	Detailed	Response Count
Building Regulations / Technical Standards	3.3% (3)	5.5% (5)	22.0% (20)	56.0% (51)	13.2% (12)	91
Codes of Practice / British Standards	3.4% (3)	5.6% (5)	34.8% (31)	47.2% (42)	9.0% (8)	89
Scottish Health Technical Memorandums (SHTM)	2.2% (2)	8.8% (8)	27.5% (25)	46.2% (42)	15.4% (14)	91
Scottish Health Building Notes (SHBN)	5.5% (5)	15.4% (14)	31.9% (29)	36.3% (33)	11.0% (10)	91
Scottish Health Planning Notes (SHPN)	9.9% (9)	20.9% (19)	28.6% (26)	31.9% (29)	8.8% (8)	91
Clinical Output Specifications	14.3% (13)	20.9% (19)	29.7% (27)	27.5% (25)	7.7% (7)	91
					answered question	**91**
					skipped question	**14**

Sustainable Hospital Refurbishment PhD

SurveyMonkey

Please indicate your level of familiarity with the following tools and systems.

	None	Very little	Moderate	Good	Detailed	Response Count
Activity Data Base (Online room data sheets/layouts etc)	5.5% (5)	14.3% (13)	33.0% (30)	33.0% (30)	14.3% (13)	91
Building Research Establishment Environmental Assessment Method (BREEAM)	4.4% (4)	7.8% (7)	27.8% (25)	42.2% (38)	17.8% (16)	90
Leadership in Energy Management & Environmental Design (LEED)	22.0% (20)	35.2% (32)	24.2% (22)	14.3% (13)	4.4% (4)	91
Achieving Excellence Design Evaluation Toolkit (AEDET)	9.9% (9)	22.0% (20)	31.9% (29)	26.4% (24)	9.9% (9)	91
ISO 14001 Environmental Management Systems	14.3% (13)	16.5% (15)	36.3% (33)	20.9% (19)	12.1% (11)	91
ISO 16001 Energy Management Systems	22.2% (20)	35.6% (32)	26.7% (24)	7.8% (7)	7.8% (7)	90
Green Guide to Specification	18.9% (17)	28.9% (26)	28.9% (26)	15.6% (14)	7.8% (7)	90
Healthcare Associated Infection System for Controlling Risk in the Built Environment (HAI-SCRIBE)	6.6% (6)	9.9% (9)	23.1% (21)	36.3% (33)	24.2% (22)	91
					answered question	91
					skipped question	14

The following is a set of statements about attitudes to the BREEAM assessment as a tool for use in healthcare refurbishment projects. Please select appropriate box.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Response Count
BREEAM is an appropriate tool for hospital refurbishment projects	11.4% (10)	26.1% (23)	27.3% (24)	29.5% (26)	5.7% (5)	88
BREEAM ensures that the project pursues best 'Value for Money'	19.3% (17)	45.5% (40)	25.0% (22)	10.2% (9)	0.0% (0)	88
BREEAM is a good reference document for the Client and/or Design Team (Architect, Engineer, Contractor)	3.4% (3)	8.0% (7)	22.7% (20)	63.6% (56)	2.3% (2)	88
BREEAM is generally well understood by the Client (NHS)	3.5% (3)	41.9% (36)	24.4% (21)	27.9% (24)	2.3% (2)	86
BREEAM is generally well understood by the Design Team (Architect, Engineer, Contractor)	1.1% (1)	14.8% (13)	18.2% (16)	54.5% (48)	11.4% (10)	88
Given the choice; I would always use BREEAM for hospital refurbishment projects	13.6% (12)	33.0% (29)	31.8% (28)	18.2% (16)	3.4% (3)	88
					answered question	88
					skipped question	17

Sustainable Hospital Refurbishment PhD

Are there any other assessment or monitoring tools, or sustainability issues relating to healthcare which you feel should have been included within this section of the questionnaire? Please state:

	Response Count
	17
answered question	17
skipped question	88

Page 3, Q1. Are there any other assessment or monitoring tools, or sustainability issues relating to healthcare which you feel should have been included within this section of the questionnaire? Please state:

1	Greencode	Dec 4, 2012 1:08 AM
2	greencode	Dec 3, 2012 8:25 AM
3	no	Nov 27, 2012 9:16 AM
4	No	Nov 26, 2012 7:11 AM
5	No	Nov 21, 2012 12:31 PM
6	None	Nov 7, 2012 10:09 PM
7	No	Oct 23, 2012 8:50 AM
8	Yes. Flexibility of Design (may be covered under future proofing) and soft landings. And for the NHS the separation of capital and maintenance budgets (project managers are under pressure to take decisions to cut project costs, that lead to higher maintenance costs. Also, what is 'sustainable' for one project is not necessarily sustainable for another. BREEAM can be a helpful tool, but not on its own. It focuses on general standards. A refurb project should have its own specific sustainability implementation plan that will require teams to deliver the BREEAM criteria that add value to the building, and that deals with all of the above issues and ensure that those measures that are appropriate are adopted, and those that aren't, are not.	Oct 23, 2012 7:39 AM
9	No	Oct 20, 2012 7:29 AM
10	Aforability	Oct 18, 2012 6:29 AM
11	Encode	Oct 18, 2012 5:26 AM
12	ASPECT	Oct 15, 2012 2:18 AM
13	NHS Scotland Greencode (an EMS)	Oct 11, 2012 6:06 AM
14	NEAT - used in England	Oct 11, 2012 2:53 AM
15	NEAT	Oct 10, 2012 5:37 AM
16	No	Oct 9, 2012 2:08 AM
17	good corporate citizen	Oct 9, 2012 12:51 AM

Working on the assumption, that the NHS as the Client, and the Design Team/Principal Supply Chain Partner (PSCP) are framing their investment objectives and decisions within the NHS Scotland strategy (of 'Person Centred, Safe, and Effective'.) How relevant in element/material/component specification terms, do you consider the patients/general public to be in the 'actual decision making processes' against each of the following issues? ('1' being of no relevance, and '10' being of critical relevance)

	'1' No relevance	2	3	4	5	6	7	8	9	'10' Critical relevance	Rating Average	Response Count
Community	2.4% (2)	1.2% (1)	3.6% (3)	3.6% (3)	8.4% (7)	3.6% (3)	18.1% (15)	24.1% (20)	8.4% (7)	**26.5% (22)**	7.54	83
Local Environment	2.4% (2)	0.0% (0)	3.7% (3)	3.7% (3)	11.0% (9)	8.5% (7)	22.0% (18)	**30.5% (25)**	8.5% (7)	9.8% (8)	7.06	82
Design Quality	3.6% (3)	10.8% (9)	8.4% (7)	9.6% (8)	10.8% (9)	8.4% (7)	9.6% (8)	**14.5% (12)**	9.6% (8)	**14.5% (12)**	6.08	83
Flood Risk & Urban Drainage	14.5% (12)	16.9% (14)	18.1% (15)	7.2% (6)	**19.3% (16)**	3.6% (3)	4.8% (4)	8.4% (7)	2.4% (2)	4.8% (4)	4.20	83
Future Proofing	8.4% (7)	15.7% (13)	8.4% (7)	10.8% (9)	**20.5% (17)**	2.4% (2)	4.8% (4)	12.0% (10)	12.0% (10)	4.8% (4)	5.12	83
Health & Well-Being	3.7% (3)	1.2% (1)	2.4% (2)	7.3% (6)	**18.3% (15)**	9.8% (8)	13.4% (11)	17.1% (14)	9.8% (8)	17.1% (14)	6.82	82
Energy and Carbon Emissions	10.8% (9)	**19.3% (16)**	13.3% (11)	10.8% (9)	12.0% (10)	9.6% (8)	3.6% (3)	8.4% (7)	6.0% (5)	6.0% (5)	4.58	83
Transport	2.4% (2)	0.0% (0)	0.0% (0)	15.9%	14.6%	6.1% (5)	17.1%	15.9%	**20.7%**	7.3% (6)	6.82	82
Water Use	8.5% (7)	**19.5% (16)**	17.1% (14)	13.4% (11)	11.0% (9)	7.3% (6)	7.3% (6)	8.5% (7)	3.7% (3)	3.7% (3)	4.40	82
Materials	10.8% (9)	13.3% (11)	15.7% (13)	13.3% (11)	**16.9% (14)**	9.6% (8)	3.6% (3)	3.6% (3)	10.8% (9)	2.4% (2)	4.55	83
Waste	13.6% (11)	11.1% (9)	**18.5% (15)**	9.9% (8)	17.3% (14)	8.6% (7)	7.4% (6)	4.9% (4)	3.7% (3)	4.9% (4)	4.43	81
Land Use & Ecology	6.0% (5)	4.8% (4)	12.0% (10)	13.3% (11)	**15.7% (13)**	14.5% (12)	10.8% (9)	12.0% (10)	7.2% (6)	3.6% (3)	5.43	83
Pollution	9.8% (8)	6.1% (5)	13.4% (11)	7.3% (6)	**17.1% (14)**	7.3% (6)	8.5% (7)	12.2% (10)	14.6% (12)	3.7% (3)	5.46	82
											answered question	**83**
											skipped question	**22**

Sustainable Hospital Refurbishment PhD SurveyMonkey

What is your level of understanding of the 'Scottish Capital Investment Manual'? (SCIM)

	Response Percent	Response Count
None	15.7%	13
Poor	21.7%	18
Reasonable	30.1%	25
Good	26.5%	22
Excellent	6.0%	5
answered question		83
skipped question		22

Sustainable Hospital Refurbishment PhD

Are you familiar with the 'Property Appraisal Guidance for NHS Scotland' document?

	Response Percent	Response Count
Yes	50.0%	42
No	50.0%	42
	answered question	84
	skipped question	21

Sustainable Hospital Refurbishment PhD

In your experience and/or opinion; are the findings of the 'Property Asset Register' or PAMS document, discussed as key factors in the initial appraisal or outline design phase of a potential refurbishment project?

	Response Percent	Response Count
Never	6.3%	3
Not very often	16.7%	8
Sometimes	35.4%	17
Mostly	14.6%	7
Always	20.8%	10
Unsure	6.3%	3
	answered question	48
	skipped question	57

Sustainable Hospital Refurbishment PhD

Have you ever participated in, or facilitated, a process that has involved 'Multi-Criteria Decision Modelling' (MCDM) techniques?

	Response Percent	Response Count
Yes (proceed to question 18)	4.8%	4
No (go to question 19)	86.9%	73
Don't know (go to question 19)	8.3%	7
	answered question	84
	skipped question	21

Sustainable Hospital Refurbishment PhD

If you answered 'Yes' to question 17; please (to the best of your recollection) state the type of MCDM model/process used, and the purpose for its use.

	Response Percent	Response Count
Type of MCDM used	100.0%	4
Purpose of use	100.0%	4
	answered question	4
	skipped question	101

Sustainable Hospital Refurbishment PhD

What is your level of familiarity with each of the following software platforms?

	None	Poor	Reasonable	Good	Excellent	Response Count
MS Access	13.8% (11)	25.0% (20)	38.8% (31)	18.8% (15)	3.8% (3)	80
Visual Basic	48.7% (38)	33.3% (26)	12.8% (10)	3.8% (3)	1.3% (1)	78
MS Excel	1.2% (1)	2.4% (2)	10.7% (9)	45.2% (38)	40.5% (34)	84
					answered question	85
					skipped question	20

What is your level of familiarity with each of the following software platforms?

	None	Poor	Reasonable	Good	Excellent	Response Count
MS Access	13.8% (11)	25.0% (20)	38.8% (31)	18.8% (15)	3.8% (3)	80
Visual Basic	48.7% (38)	33.3% (26)	12.8% (10)	3.8% (3)	1.3% (1)	78
MS Excel	1.2% (1)	2.4% (2)	10.7% (9)	45.2% (38)	40.5% (34)	84
					answered question	85
					skipped question	20

Page 4, Q1. In the context of healthcare refurbishment; please provide a brief statement on what you consider the definition of 'Value for Money' to be.		
1	Fulfilling stakeholder's objectives with minimal disruption to core business activities.	Dec 4, 2012 6:10 AM
2	Expenditure that achieves the appropriate facility and quality at the most reasonable cost	Dec 4, 2012 1:16 AM
3	Needs metas opposed to wants at the righ price with the right quality.	Dec 3, 2012 12:03 PM
4	Value for money is only relevant in the overall/big picture, in light of the whole asset/collection of sites	Dec 3, 2012 9:21 AM
5	public opinion	Dec 3, 2012 8:36 AM
6	Achieving a measurable benefit which when compared with other developments represents improved patient outcomes at a cost that is not outlandish when considering the benefit gained.	Dec 3, 2012 6:49 AM
7	predicated on the best use of the existing estate it is essential to maintain the existing estate to minimum standards as the previous investment programme is not sustainable, nor practical.	Dec 3, 2012 6:21 AM
8	A facilty that is fit for purpose & is as energy efficient as possible.	Nov 29, 2012 2:13 AM
9	enabling the service provision from the existing buildings to be improved to current standards at a lesser cost than new build: One the basis of a long term strategy/plan	Nov 27, 2012 9:21 AM
10	Providing an environment in which better facilities allow for the provision of better services in a safe and easily accessible facility.	Nov 26, 2012 7:16 AM
11	Value for money is the best use of available resources to acheive the best outcome in terms of design, environment and energy efficiency	Nov 23, 2012 7:45 AM
12	A development that suits the needs of current patients; however, will be relevant for future generations and can be adapted/upgraded easily	Nov 21, 2012 12:35 PM
13	Low lifecycle cost, even if this means higher build cost. Too often stakeholders do not look beyond the initial build cost which almost always results in a higher lifecycle cost. My thoughts can be summed up by the following saying - "quality remains long after the cost is forgotten".	Nov 19, 2012 9:58 AM
14	Providing the Client with a functional building which is tailored to their specific needs.	Nov 16, 2012 2:29 AM
15	A product that functions in the way it was designed to do so delivered within budget	Nov 12, 2012 11:15 PM
16	capital costs plus running costs over benefit compared to market	Nov 8, 2012 5:07 AM
17	A building which delivers the desired EPC within Budget.	Nov 8, 2012 2:43 AM
18	Providing a product that meets its specific purpose at the lowest possible cost but whilst taking into consideration the impact on the environment.	Nov 8, 2012 1:25 AM
19	risk based collected lifespan value	Nov 7, 2012 10:13 PM
20	good quality build for a resonable cost per cubic metre	Nov 7, 2012 2:20 PM

Page 4, Q1. In the context of healthcare refurbishment; please provide a brief statement on what you consider the definition of 'Value for Money' to be.		
21	an appropriate level of expenditure to fulfil the clinical requirement	Nov 7, 2012 4:55 AM
22	refurbishment to ensure 25 years use without further works.	Nov 1, 2012 3:02 AM
23	finished product that best fits the balance between contractors commercial interests and clients need to get quality that is cost affordable, meets criteria an dis competitive when compared against typical or market equivilants	Oct 31, 2012 8:57 AM
24	Making the best compromise of quality within your budget constraints	Oct 31, 2012 6:29 AM
25	Fit for purpose and value engineered with low operrating and maintenance costs with long life expectancy	Oct 25, 2012 3:04 AM
26	A good quality building being sighted in the right area for the patient group that it is focusing on.	Oct 25, 2012 12:51 AM
27	The design solutuionwhich best meets the clients bneeds in terms of utility sustainability and fitness for pupose at the most economical cosyt in termsa of capital life cycle and maintenance.	Oct 24, 2012 12:19 AM
28	The opposite of 'Buy Cheap, Buy Dear'	Oct 23, 2012 8:54 AM
29	Robust and flexible designs, properly thought through to meet the needs of the users over the life cycle. Efficiently and cost-effectively procured and delivered.	Oct 23, 2012 7:44 AM
30	Always the cheapest	Oct 23, 2012 5:38 AM
31	Cut the cost, provide a cheeper alternative	Oct 22, 2012 8:26 AM
32	Quality mordern product at a low cost	Oct 22, 2012 4:58 AM
33	The effective use of resources directed towards the project objectives	Oct 20, 2012 7:33 AM
34	clincally functional with on going energy savings through energy efficient design	Oct 19, 2012 4:41 AM
35	Project cost meets NHS affordability	Oct 18, 2012 6:33 AM
36	a building which has been designed to meet the use of all building users in the present and future with no negative impact on the environment	Oct 18, 2012 6:13 AM
37	The right buildings are built to meet the requirements of all stakeholders, particularly the end users.	Oct 18, 2012 6:12 AM
38	The delivery of a refurbished facility, not necessarily at the cheapest price, but within an affordable budget for the client, and which meets not just the clinical criteria but as far as possible takes account of environmental issues.	Oct 18, 2012 2:34 AM
39	Ensuring optimum return on investment throughout the remaining useful life, by maintaining a fit for purpose, safe and compliant, functionally suitable facility.	Oct 18, 2012 2:29 AM
40	Value for money at the beinging of a project often means ensuring good quality, low maintance, low running costs and good Life Cycle value, but often by the end of a project it means how much can we get for our money with comprimises being made on quality and material specification, which in	Oct 18, 2012 12:59 AM

Page 4, Q1. In the context of healthcare refurbishment; please provide a brief statement on what you consider the definition of 'Value for Money' to be.		
	the long run increase maintenance, running and life cycle costs.	
41	Achieving a "best value" design solution that addresses the needs of the service	Oct 17, 2012 5:15 AM
42	Value is where the benefit exceeds the cost in a demonstrable way	Oct 16, 2012 5:35 AM
43	A solution that is affordable, appropriate and sustainable	Oct 15, 2012 2:22 AM
44	meeting clinical effectiveness requirements at a cost that provides good quality, durable, finishes and facilitates ease of maintenance	Oct 11, 2012 6:14 AM
45	best price for the lifecycle of the building within resources	Oct 11, 2012 5:15 AM
46	the ability insert a modern facility into an existing fabric that utilises te best design principles to enhance patiernt care.	Oct 11, 2012 4:12 AM
47	Improving service and reducing cost	Oct 11, 2012 2:30 AM
48	Delivery of a product / service that is fit for pupose and affordable	Oct 10, 2012 5:45 AM
49	capital investement should concentrate on making best use of the existing estate before laying down new fioundations. as such, the existing estate requires backlog investment to meet current standards, but is a cheaper and in particular more pragmatic solution given the current fiscal status	Oct 10, 2012 4:02 AM
50	The best result for the refurbishment that best suits NHS/patients requiremnets for the lowest cost.	Oct 9, 2012 1:07 AM
51	benefits over the life of a building	Oct 9, 2012 1:04 AM
52	attaining the correct specification for the project. e.g. Not making a simple heating system which works have a building management system which costs more than it will ever save and which probably took more carbon to make than it will ever save.	Oct 9, 2012 12:58 AM
53	Changes made benefit healthcare provision enough to justify the cost of the project	Oct 9, 2012 12:35 AM
54	Maximum asset life at minimum whole life cost	Oct 8, 2012 11:28 PM
55	The most cost effective and sustainable solution to adress and identified requirement or risk.	Oct 8, 2012 11:13 PM
56	The biggest benefit possible for each pound spent in terms of provision of healthcare, building futureproofing, and energy efficiency	Oct 8, 2012 10:53 PM
57	Where the product is equal or better than could have been achieved as a Commercial client - i.e. not the Public Sector levels but actually comparable to the private and, where comparable, the Domestic sectors	Oct 8, 2012 11:56 AM

User Guide

An Integrated Decision Support Model for the Sustainable Refurbishment of Hospitals and Healthcare Facilities

Grant Wilson

Contents

List of Figures

1. Introduction

The Decision Support Model (hereafter referred to as the 'DSM') is a software based decision support system, designed specifically to facilitate, inform, and support the decision making process for material/component/systems specification, for the sustainable refurbishment of hospitals and healthcare facilities.

The DSM is designed for use by the integrated NHS asset/estates management professionals, and the refurbishment works design teams and contractors, or Principal Supply Chain Partners (PSCPs)

The DSM utilises the Microsoft Excel® software platform, and is supported by pre-loaded documentation and guidance documents, and where required, by direct web links by means of an operating internet connection.

The Graphical User Interface (GUI) is macros protected, with only the relevant user input cells open for user manipulation. The DSM is constructed by a series of sequenced worksheets which appear in the following format:

- Cover Page
- Project Information
- Maps and Guidance
- Sustainability Drivers
- Associated Guidance
- Criteria Selection
- Options Selection
- Decision Support Model
- User Guide

This User Guide will describe the models function in the same order as the worksheets are presented in the list above. To allow for a detailed demonstration of the models functions, a case study has been used for demonstration purposes. The case study is based on a real life project, although the decision-making processes described have been input by the models designer, and are in no way the actual decisions and specifications agreed within the case studies business case process.

2. DSM File Structure

Please refer to the attached 'DSM Prototype' CD for additional guidance.

The DSM Master file is pre-loaded with the following PDF templates, folders, and Excel template.

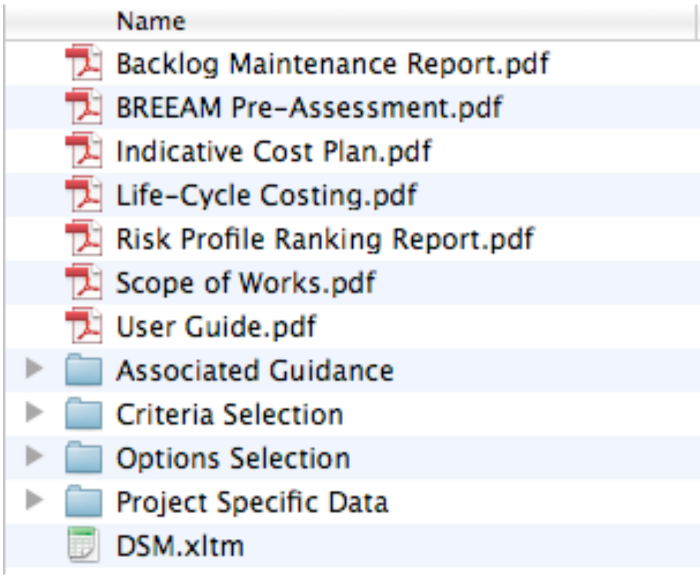


Figure 1: File Structure

The following points must be noted regarding the files displayed in Figure 1.

PDF files – Excluding the 'User Guide', all of these files are blank templates. Each project will save the required documents for all other PDFs with the file names shown in Figure 1.

Folders – All of the folders shown in Figure 1 are pre-set. The only folder which will require user input is the 'Project Specific Data' folder, and this will be described in a later section. All other folders should remain untouched.

DSM.xltm - The DSM.xltm file is a template file. This file cannot be used directly for any given project, but must be saved as an xlsm (Excel Macro – Enabled Workbook) for each individual project.

3. Creating a New Project

Please refer to the attached 'DSM Prototype' CD for additional guidance.

1) 'Save as' the DSM Master File with the required project name. Figure 2 shows this as the case study (ARI Phase 2 Demo)

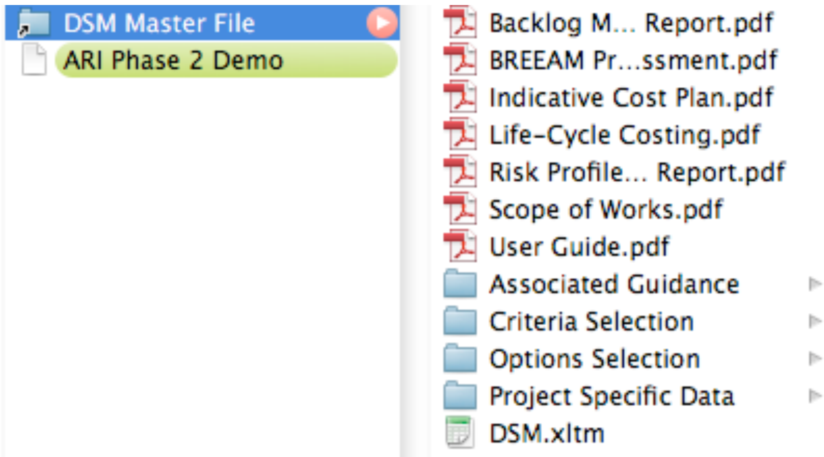


Figure 2: 'Save' Master File as new named project

2) In the newly saved project file (ARI Phase 2 Demo) 'Save as' the DSM.xltm (template) file as an xlsm file with the projects name (Figure 3) ***It is critical that the template is saved as a new Excel file, as the DSM.xltm file will not function***

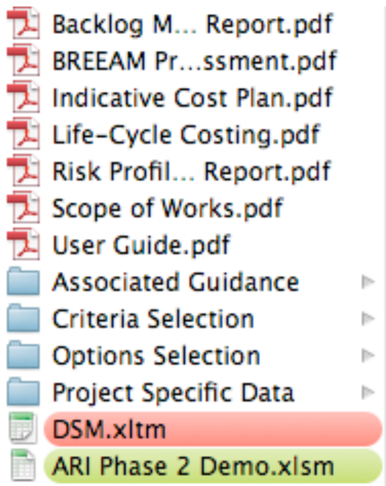


Figure 3: Save xltm file to project specific xlsm file

3) With the exception of the 'User Guide' PDF, **import** all of the project PDF documents shown in Figures 1, 2 and 3, with the exact file names shown. These will now be accessible through the model.

4. Cover Page

Upon opening the DSM, a will appear asking if the user wishes to enable or disable the file macros. Press the 'enable macros' button (Figure 4)

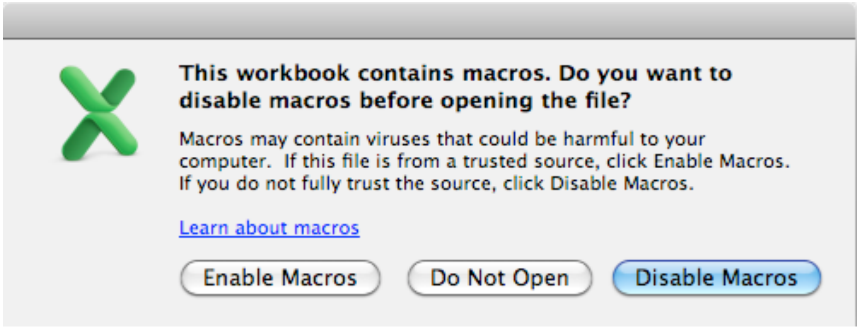


Figure 4: Select 'enable macros'

The Cover Page will now appear (Figure 5) It should be noted that the DSM is compatible with both Macintosh® and Microsoft Windows® operating systems. The file structure and screenshots used throughout the User Guide are taken from a Macintosh system, although there are very few differences between the two GUIs. The only noticeable difference on a Windows platform, from that shown in Figure 5, is that the Windows version would hide the Excel ribbon across the top of the GUI.

Figure 5: Cover Page (Macintosh version)

5. Project Information

The Project Information page is separated into two main sections (Figure 6). These are:

1 – Project Information
2 – Facility Elements and Sub-elements

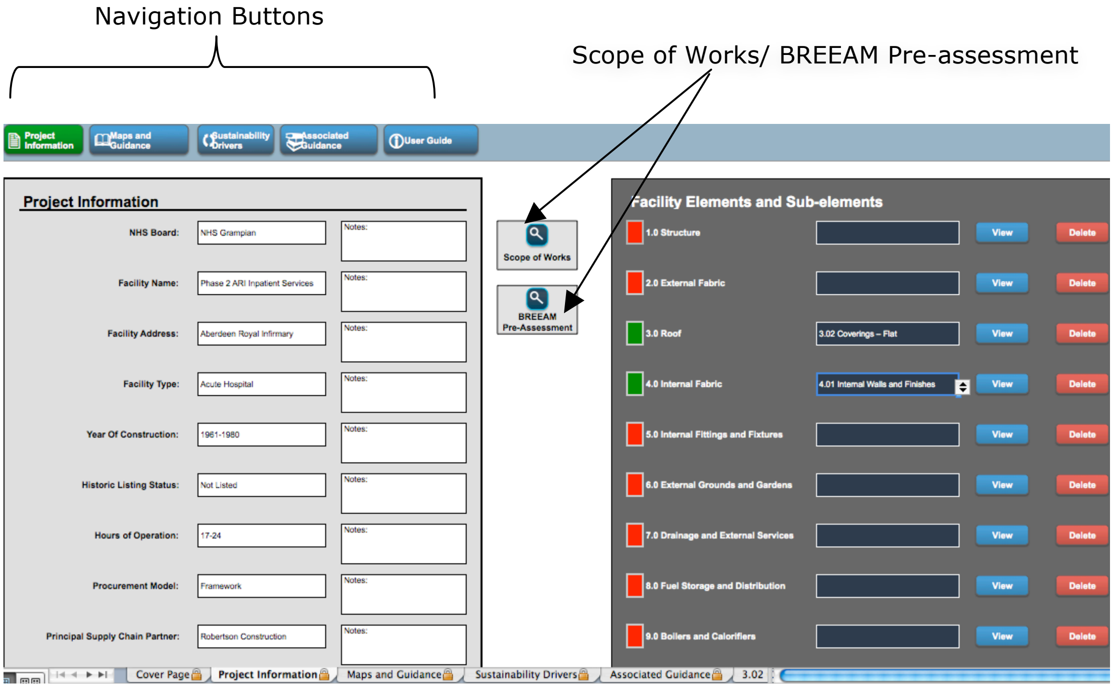


Figure 6: Project Information Page

Figure 6 shows the two main sections on the left and right, respectively.

Navigation Buttons

The navigation buttons indicated in Figure 6, may be used to take the user to the specified worksheet/model function. The Excel worksheet tabs shown along the bottom of the GUI may also be used for this purpose.

Scope of Works

The Scope of Works will inform and guide the selection of Elements and Sub-elements (in the standard business case, this will be taken from the Initial Agreement document) The user will save the Scope of Works as a PDF document within the file structures discussed previously. This will enable a direct link by use of the button displayed in Figure 6.

BREEAM Pre-Assessment

This may be uploaded using the same system as described for the Scope of Works. The BREEAM requirements may have significant bearing on system/element/component selection and specification.

Project Information Section

The information inputs required within this section, are a combined system of pre-set drop down menus, and where necessary, text entry direct from the user. This section will provide all of the required information required for the project.

Facility Elements and Sub-Elements
Used in conjunction with the Scope of Works document, this section allows the user to select the main elements and sub-elements that have been identified for refurbishment, maintenance, or replacement. All of the elements and sub-elements are selected by use of drop down menus (Figure 7)

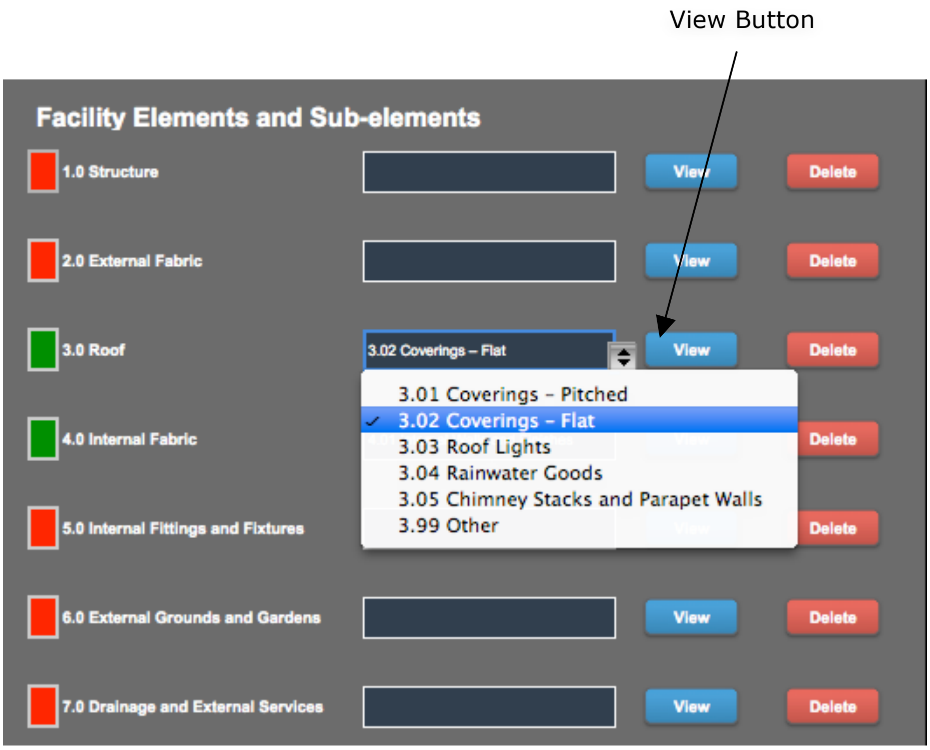


Figure 7: Element and Sub-element selection

View Button
Upon selection of the identified sub-element, the user presses the view button, and the decision making process will automatically be refreshed to display the 'Criteria Selection' worksheet. The Criteria Selection worksheet will be described later in the user guide.

6. Support Functions

Placed ahead of the main decision making pages, the DSM provides three worksheets designed in the support function. These are:

1) Maps and Guidance
2) Sustainability Drivers
3) Associated Guidance

Maps and Guidance

This describes and illustrates the wider decision making process, and the steps contained within. Also provided, is a generic flow diagram of the high level decision making pathways.

Sustainability Drivers
The purpose of the Sustainability drivers worksheet is twofold. In the first instance, it is intended as an aide memoire for the decision maker/model user on the most commonly found Sustainably issues. The summarised issues themselves, are developed from the RICS Ska assessment (https://ska-tool.rics.org/) The main issues are:

- Energy
- Material Issues
- Pollution Issues
- Transport Issues
- Waste Issues
- Water Issues
- Wellbeing Issues

The second function of the Sustainability drivers worksheet is to stimulate conversation between the decision makers, and to focus the discussion on sustainability related issues regarding the projects Scope of Works.

Associated Guidance
This worksheet is linked to the main legislation, regulation, and guidance documents identified as relevant to the decision making process. Listed in alphabetical order, the guidance is intended to inform and direct the Criteria Selection process (extract shown in Figure 8)

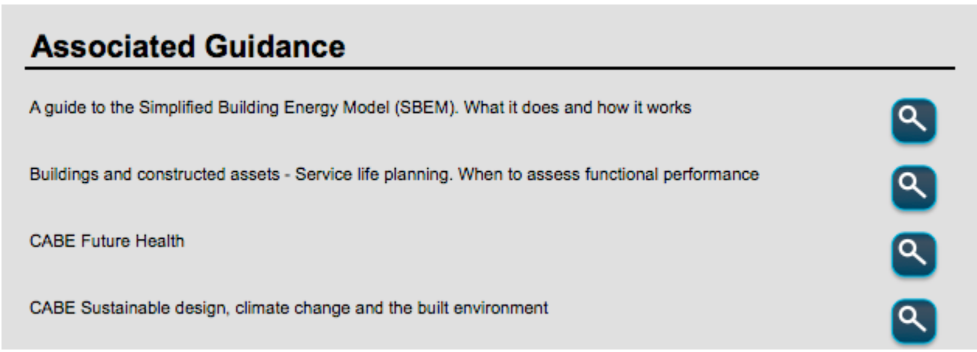


Figure 8: Extract from Associated Guidance

7. Criteria Selection

As described previously; Figure 7 illustrates the 'View' button following the selection of the identified sub-element. Once pressed, this will automatically take the user to the Criteria Selection page. The page is separated into three main sections. These are:

1) Criteria Selection
2) Criteria Guidance

3) Relevant Standards and Publications

Criteria Selection

This section is separated into three phases. Phase 1 is completed before continuing to Phase 2. Phase 2 is completed before continuing to Phase 3.

Phase 1 – Initial Criteria

Figure 9 illustrates the design of Phase 1. The 'Technical Standards', and all of the 'Scottish Health Technical Memorandum' (SHTM) documents are pre-set within the file structure described in Section 2 of the user guide.

The 'BREEAM assessment', and the 'AEDET assessment' shown in Figure 9 are web-links which will navigate the user to the respective homepage of each model. Internet connection will be required for this process.

The 'Initial Agreement' (IA) heading is an aide memoire for the decision maker, to include the requirements within the IA within the criteria selection process.

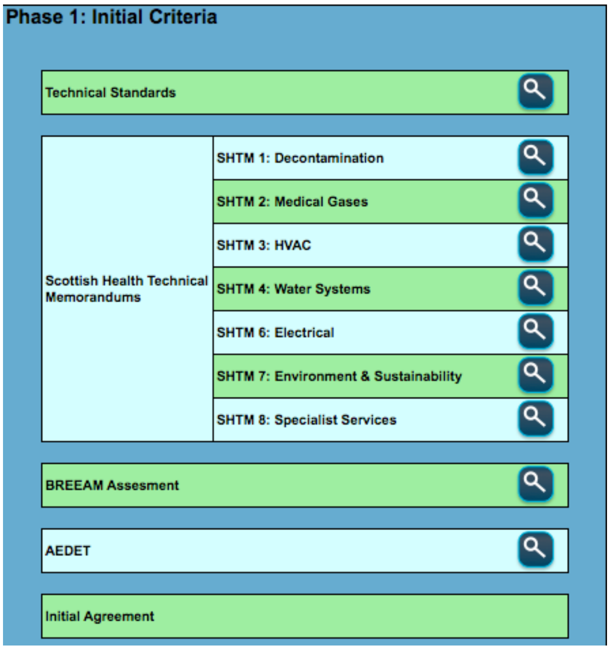


Figure 9: Phase 1 / Criteria Selection

This phase is designed to allow the decision maker to identify the high level, and the mandatory criteria requirements for the project.

Phase 2 – Potential Criteria

Figure 10 illustrates the design of Phase 2. This phase of the process has no file or web links, and is intended as a guidance aide memoire function. The Initial Agreement shortlist provides the first section, following on from the final section in Phase 1.

The '6 facets' mirror NHS Scotland's own *Property Appraisal Guidance* document, and should be read in conjunction with the results (where available) of the *Estates Manager* tool.

The 'Project Specific Criteria' directs the decision maker to consider the refurbishment activity as a unique project.

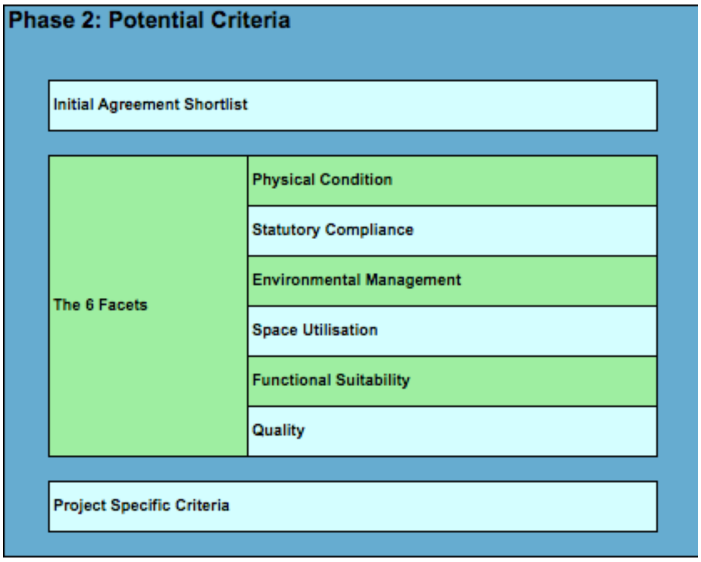


Figure 10: Phase 2 / Criteria Selection

Phase 2 (in common with the over-riding aims of the whole model) is intended to generate discussion and facilitate consensus of the decision making group.

Phase 3 – Final Criteria

The final phase of the criteria selection process; Phase 3 is the input phase from the model user. There are 10 criteria options available within the model. A minimum of 2 criteria must be selected to generate the decision-making framework (discussed later in the user guide)

Figure 11 shows the final criteria selected in terms of the exemplar case study discussed in Section 1. It is noted that the term 'criteria', in the context of the DSM (and those illustrated in Figure 11) refers to aspects of the decision making process or specification requirements, which are either mandatory, or deemed by the decision maker as *being of importance* to the project.

Phase 3: Final Criteria	
A	Thermal Performance - Warm Roof Required - U Values (W/m2K) = 0.25 (notional building)
B	Environmental Performance (HTM 07-07 pp.52) SuDS, Green Roof, Permeable surfaces etc
C	BREEAM Requirement
D	AEDET Requirement
E	Maintenance Availability
F	Guaranteed Source of Materials & Contractor
G	Minimal Disruption to services throughout Works Programme
H	
I	
J	

Figure 11: Phase 3 / Criteria Selection

The final criteria selected (Figure 11) are assessed and compared against the other two main sections of the Criteria selection worksheet. These are described below.

Criteria Guidance

Once Phases 1 and 2 have been undertaken, to provide a list of final criteria (Phase 3), the 'Criteria Guidance' section is consulted as an aide memoire, to review an extensive list of suggested criteria options. These are not mandatory for use in the DSM, however may provide a useful reference for the model user.

Relevant Standards and Publications

It was described earlier, that the identified 'key' documents and guidance, have been provided as linked files in the 'Associated Guidance' worksheet. This section provides an extensive list of a wider range of potentially related documentation and guidance. This is a reference function for the model user.

Note:

Once the Final Criteria have been selected, the user will be offered to **Confirm Final Criteria**.

Once this has been confirmed, the Final Criteria will automatically be saved within the model and presented later in the decision-making framework. Also, the 'Options Selection' worksheet will automatically open as described in the next section.

8. Options Selection

The 'Options Selection' worksheet will automatically open upon completion and confirmation of the selected Final Criteria. The page is separated into two main sections. These are:

1) Options Selection
2) Key Suppliers by Product Group – Guidance

Options Selection
This section is separated into three phases. Phase 1 is completed before continuing to Phase 2. Phase 2 is completed before continuing to Phase 3. Following Phase 3, the 'Final Options' are input by the user.

Phase 1 – Initial Options
Figure 12 illustrates the design of Phase 1. Similar case studies are suggested by means of web searches and decision maker discussion.

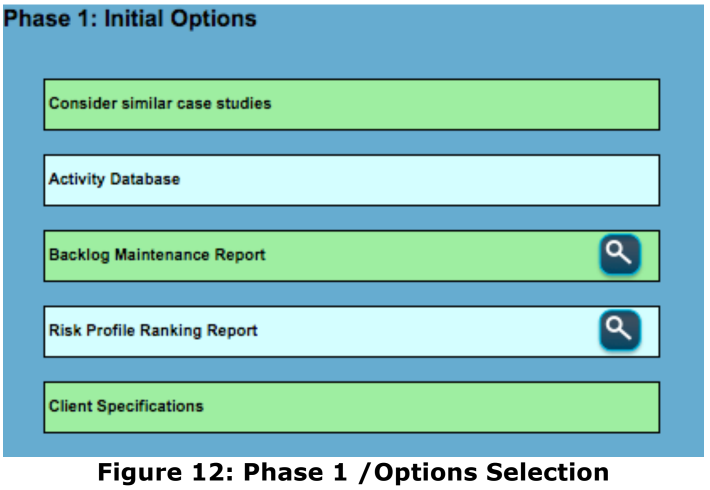


Figure 12: Phase 1 /Options Selection

The case studies are saved in the new project File Structure described in Section 3 (Figure 13)

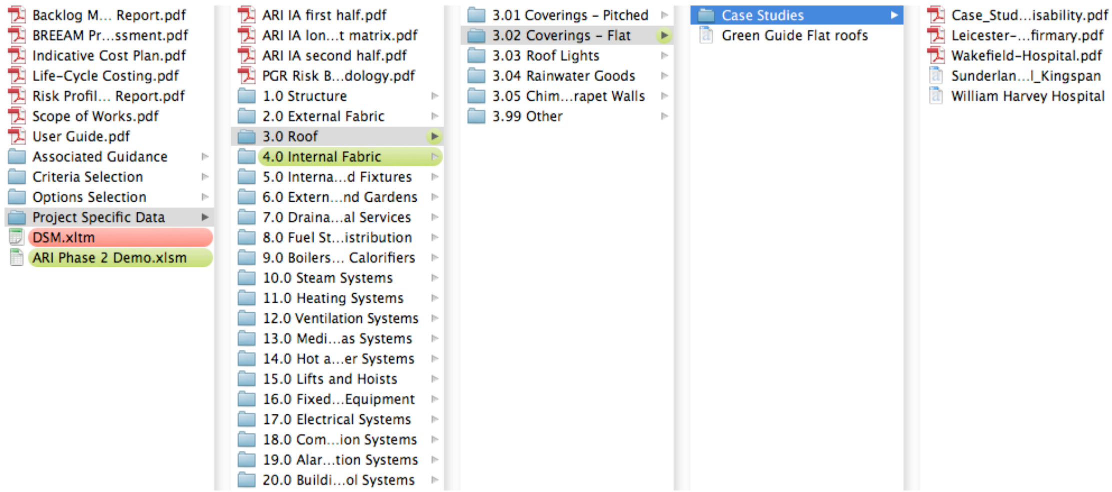


Figure 13: Saving case studies within the new projects file structure

The 'Backlog Maintenance Report' and the 'Risk Profile Ranking Report' shown in Figure 12, are direct file links, and should have been uploaded/imported by the user in PDF file format, as described in Section 3 of the user guide.

The 'Client Specifications' are presented as an aide memoire, to encourage the decision maker to review any specific specifications, or clinical output specifications, relevant to the project.

Phase 2 – Potential Options

Having carried out the higher-level options appraisal described above, and illustrated in Figure 12; Phase 2 is designed to focus in greater detail on the *potential* options that may be considered. The 'BRE Green Guide to Specification', and the 'Building Cost Information Service' (BCIS) are web linked, and will navigate the user to the sign in pages for both tools.

The 'Schedule of Life Expectancies' and the 'Schedule of Rates' are linked to the *NHS Property Appraisal Guidance* document, and support the Green Guide and BCIS in assessing utility and cost issues with regards to the budget outlined in the overall Business Case.

An aide memoire heading is also provided to encourage the decision maker to source, and discuss the proprietary literature of any systems/elements/components/materials etc., that may have begun to emerge throughout the decision making process and discussion so far. Figure 14 illustrates the design of Phase 2.

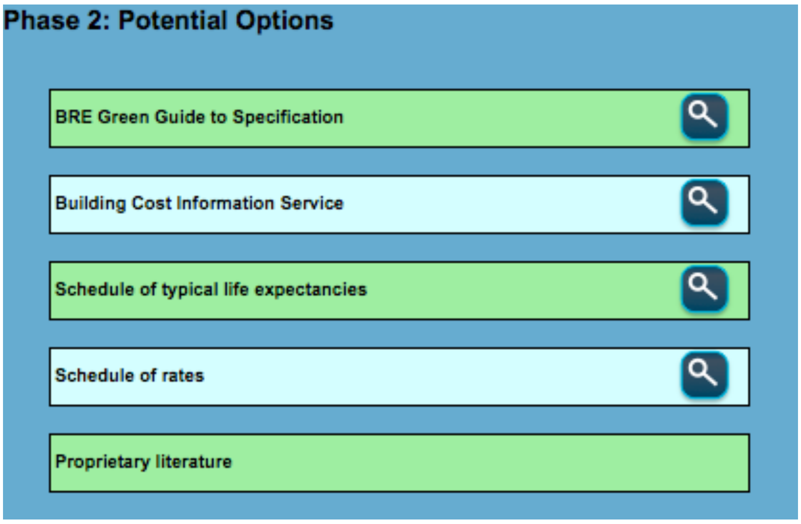


Figure 14: Phase 2 / Options Selection

Phase 3 – Final Options

Phase 3 of the Options selection process, is designed as an aide memoire section, and has the purpose of creating further and more detailed discussion from the decision maker. This covers a range of areas such as maintenance issues, legal requirements, availability etc. This phase is used in conjunction with the second section of the worksheet.

Final Options

This section requires user input in recording the agreed final set of options (Figure 15) For the purposes of the case study, the user manual has recorded these as Options A to E.

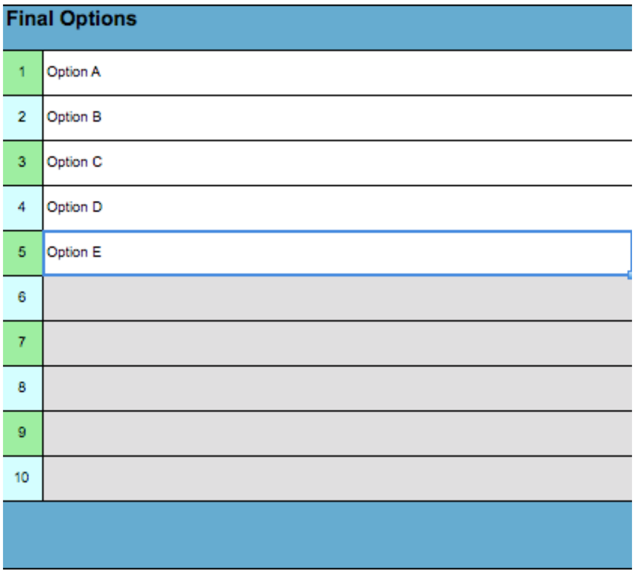


Figure 15. Final Options (User Input required)

Key Suppliers by Product Group – Guidance

This section is designed to support and inform the consideration and selection of final options choices. This may be especially useful in the context of the case studies, the cost issues, proprietary literature, and assessing the availability of systems data. Key certified, material and product suppliers across the UK have been included, and are searchable by product group through use of the internet.

Note:
Once the Final Options have been selected, the user will be offered to **Confirm Final Options**.

Once this has been confirmed, the Final Options will automatically be saved within the model and presented later in the decision-making framework. Also, the 'Decision Support Model' worksheet will automatically open as described in the next section.

9. Decision Support Model

The 'Decision Support Model' worksheet will automatically generate once the Final Options have been confirmed. The worksheet is separated into three main sections. These are:

1) Decision Support Model framework(s)
2) Non-Financial Preference Ranking chart
3) Benefit to Cost Preference Ranking chart

Note:
Items 1 and 2 stated above (charts) will automatically update as Decision Support Model framework is manipulated by the model user. Therefore, **no user input** is required for these parts of the model.

Decision Support Model Framework
The design of the framework is illustrated in Figure 16. The Criteria and options will be automatically input and cannot be changed within this section of the process.

Summary instructions for using the Decision Support Model framework are explained below.

1) User inputs the **Title** (Re-felting of Flat Roof for the case study)

2) Through a process of discussion and consensus, the model user compares the criterion by means of drop down menus. The reference scale is situated on the GUI and is identified as the **Importance Scale**.

3) The **Weight** values of each criterion will automatically update.

4) Through a process of discussion and consensus, the model user scores each option against each criterion by means of drop down menus. The reference scale is situated on the GUI and is identified as the **Performance Scale**.

5) The **Total Scores** will automatically update.

6) The user manually inputs the **Costs**, or estimated costs against the specification of each selected final option.

7) The **Benefit to Cost** (BTC) Ratio value will automatically update.

8) By selecting the **'Add DSM'** button, a new framework will appear. This will allow for the models criterion values to be explored through a process of basic **sensitivity analysis** (The 'Add DSM' function can be used as many times as required)

9) Non-Financial Preference, and Benefit to Cost Preference charts will automatically be updated and allow for comparison of each option following sensitivity analysis testing.

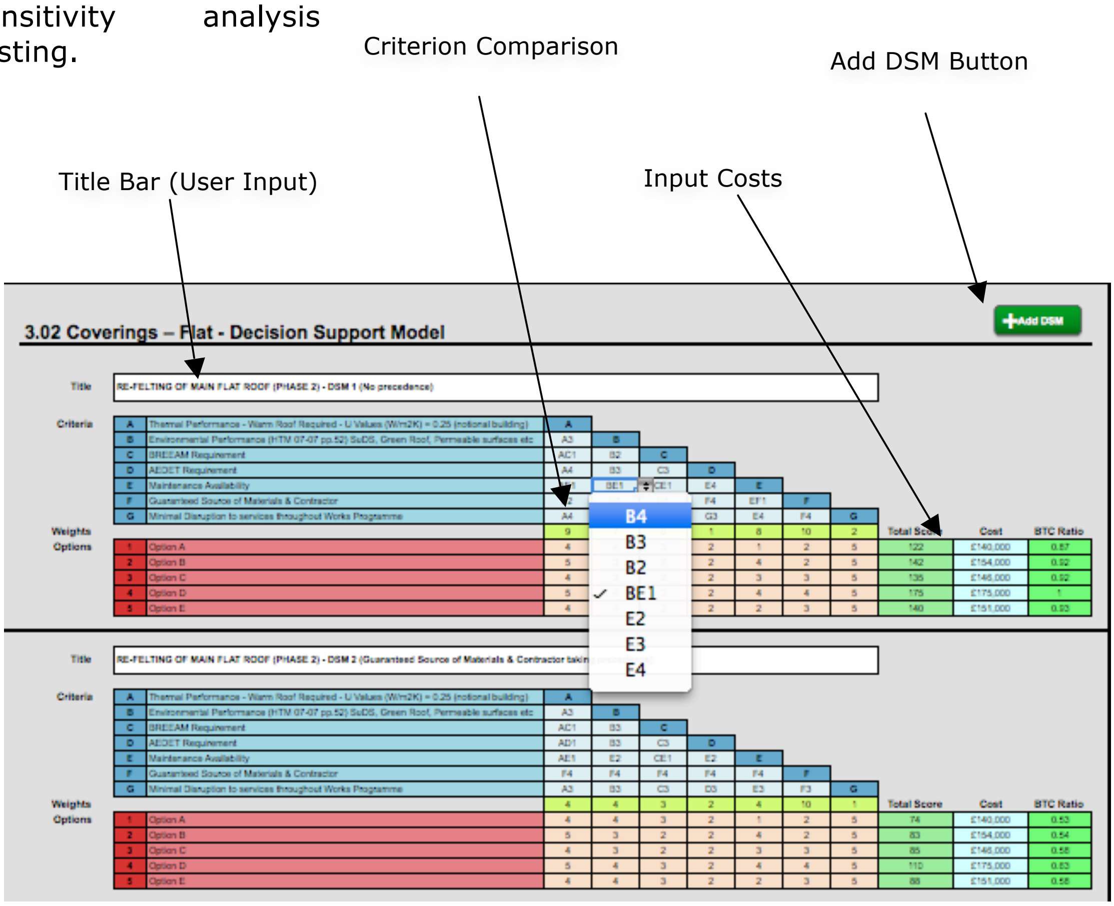
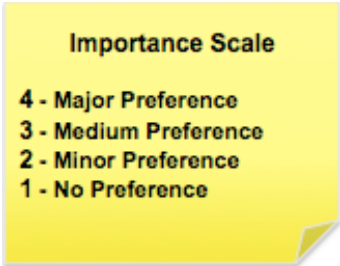


Figure 16: Decision Support Model – Framework (Showing additionally selected DSM for sensitivity analysis)

Figures 17a and 17b show the Importance Scales and the Performance Scales, for use on the Criterion comparison, and Options assessment, respectively.



17a: Criterion Selection

17b: Options Assessment

GUI Preference/Ranking charts

The 'Non Financial Preference Ranking' chart, and the 'Benefit to Cost preference Ranking' chart are illustrated (in the context of the case study) in Figure 18.

Each DSM process is scored and compared by colour coding, and a summary of the criterion preferences (taken from the Title bar – user input) is provided for reference alongside each chart.

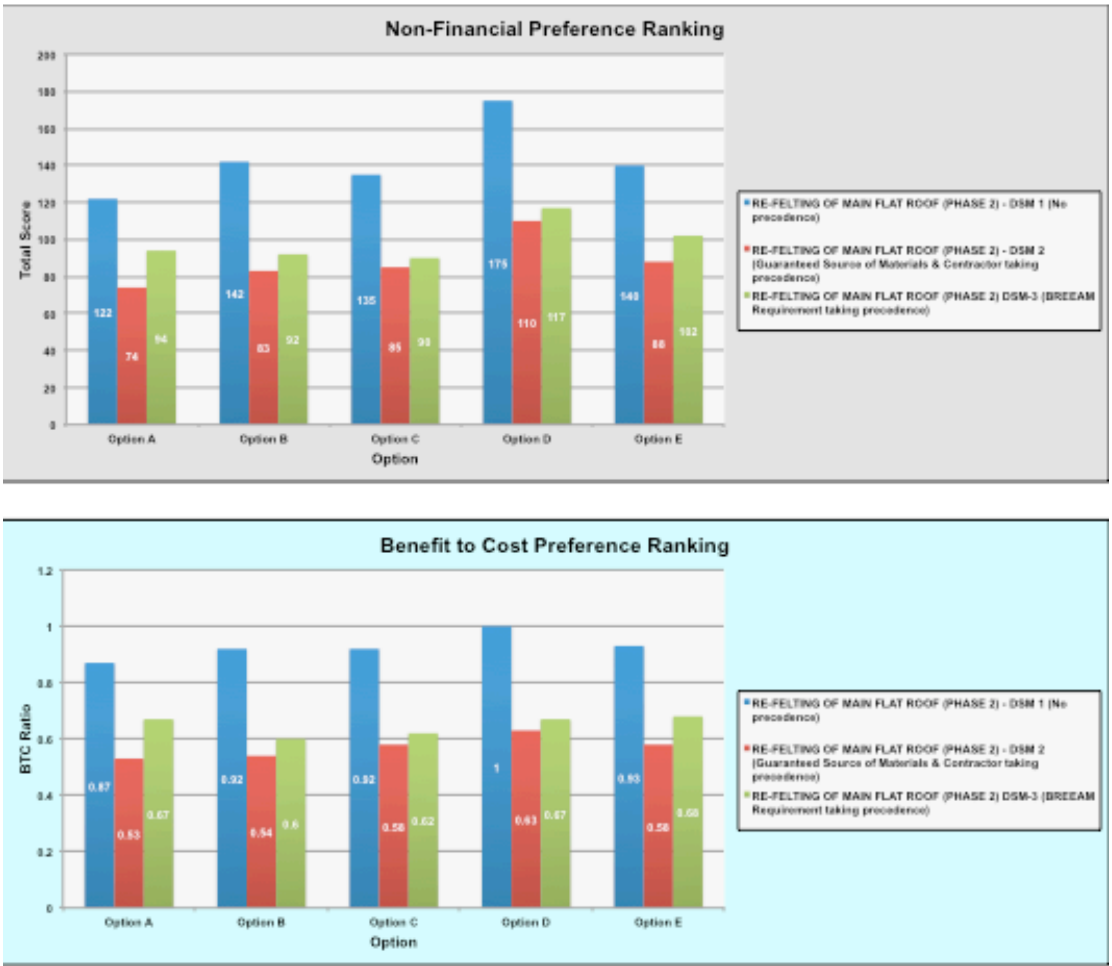


Figure 18: Non Financial Preference Ranking' chart, and the 'Benefit to Cost preference Ranking' chart

Upon completion of the sensitivity analysis and selection process, the user inputs the 'Preferred Option' into the box provided on the GUI.

10. Next Steps

Upon completion of the Decision Making process and Option selection described in Section 9, the user may return to the 'Project Information' page (Figure 6)

The process may now be repeated by selection of a different main element, or sub-element. The process will automatically update in exactly the same way as described for the example given in the user guide.

Each completed DSM Element, will be recorded and saved in the worksheet tabs, by means of a red identification tab, which corresponds with the coding protocols of the NHS Scotland Property appraisal guidance document (Figure 19) This is intended for ease of location in preparing a final report on the combined decision making processes.

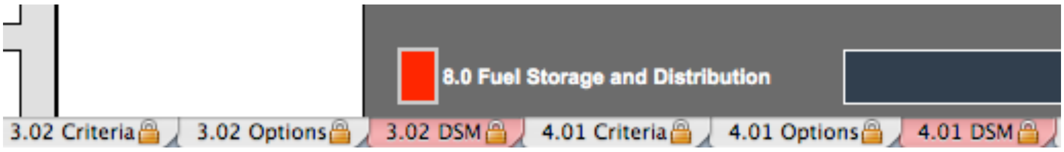


Figure 19: Completed DSMs coded in red tabs.

The saved DSM tabs (shown in red), may be deleted by the user, using the 'Delete' button on the Project Information page – Facility Elements and Sub-elements.

MEETING SUSTAINABILITY REQUIREMENTS IN THE REFURBISHMENT OF HOSPITALS

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Public spending across the United Kingdom is facing unprecedented challenges as a result of the economic downturn. Nowhere is this more keenly felt than the interface between the National Health Service (NHS) and the construction industry. Limited government investment is challenged by the ever evolving demographics and technological changes which are driving the need for flexibility and progress throughout the NHS. In tandem with these financial and evolutionary challenges, the NHS bears a legal responsibility to reduce its Carbon Footprint significantly, in line with the requirements of the Climate Change Act. Additionally, the service is driven by the organisational and legal requirements of the wider sustainability drivers. The emphasis on construction within the NHS has focused predominantly in the area of new build within the last 10 years. This paper discusses the need to focus on the area of Refurbishment. The main aim of this paper is to present a contextual basis for an ongoing research study to develop a sustainable refurbishment model for hospitals. A comprehensive literature review has been employed as the methodology to discuss the current situation relative to organisational, financial, and sustainability factors. It is demonstrated that an understanding of the nature of refurbishment is required. Challenges specific to refurbishment, such as lack of as-built data and information on the state of the existing fabric and services, may have significant effects on the project in regard to time and cost. It is further demonstrated that the hospital facility has unique characteristics and Client expectations which do not affect a 'standard' commercial refurbishment.

Keywords: NHS, refurbishment, sustainability, management, climate change act.

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A CONCEPTUAL DECISION SUPPORT MODEL FOR SUSTAINABLE HOSPITAL REFURBISHMENT

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ABSTRACT

The refurbishment of the existing healthcare estate in the UK has become far more prevalent in recent times than the new-build approach of the last decade. This coincides with ever more challenging institutional and statutory requirements in regards to sustainability. A challenging economic landscape coupled with the unique challenges and restrictions imposed by works to an existing structure presents the Client and the Design Team with the requirement to make specification and financial decisions based on a 'best fit' and 'best compromise' scenario. The sheer scale of the healthcare estate, and the unique complexity of the hospital as a facility dictate that a Multi-Criteria Decision Modelling (MCDM) approach is essential to allow for the generation of alternatives which may provide the best compromise solution to a given project. This paper discusses this challenge with specific focus on the hospital. The main aim of this paper is to present a conceptual model of the entire decision making process for the activity of sustainable hospital refurbishment. The required phases will be discussed as the core processes required as the basis for a software based interactive model.

Keywords: conceptual model, hospital, refurbishment, sustainability

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KEY CRITERIA OF SUSTAINABLE HOSPITAL REFURBISHMENT: A STAKEHOLDER REVIEW

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Hospital refurbishment has taken a secondary role in the last decade, in favour of new build facilities. This has allowed the Client and the Design Team to build and specify with greater flexibility and from essentially a 'blank canvas'. Correspondingly, sustainability as an issue has been easier to plan and implement from the earliest briefing and design stage. The changing economic landscape has necessitated that the focus has now shifted to the refurbishment of the existing healthcare estate. Refurbishment is widely recognised as presenting unique challenges in its own right. Add to this the institutional and statutory requirements in the arena of sustainability and the unique functional characteristics of an operational hospital and these challenges are increased. Given the practical and economic challenges of refurbishment as an activity, weighed against a facility as multi-faceted and complicated as a hospital, a structured and prioritised process of decision making is required. A multi-criteria decision making (MCDM) approach is discussed as being most suitable for this process. A pilot study of a non-random sample of industry experts is analysed to establish a baseline knowledge platform of the key research variables and subsequent method of selecting criteria. The overall findings establish a good awareness of sustainable development and familiarity with key documentation and guidance, however knowledge of the capital investment appraisal process and the use of MCDM tools is shown to be very limited.

Keywords: Hospitals, MCDM, refurbishment, stakeholders, sustainability.

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IDENTIFYING SUSTAINABILITY REQUIREMENTS IN THE REFURBISHMENT OF HOSPITALS: THE BUILT ESTATE, MODELS OF CARE, AND THE CHALLENGE OF ADAPTATION PLANNING

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Abstract— Public spending across the United Kingdom is facing unprecedented challenges as a result of the economic downturn. Nowhere is this more keenly felt than the interface between the National Health Service (NHS) and the construction industry. Limited government investment is challenged by the ever-evolving demographics and technological changes which are driving the need for flexibility and progress throughout the NHS. In tandem with these financial and evolutionary challenges, the NHS bears a legal responsibility to reduce its Carbon Footprint significantly, in line with the requirements of the Climate Change Act. Additionally, the service is driven by the organisational and legal requirements of the wider sustainability drivers. The emphasis on construction within the NHS has focused predominantly in the area of new build within the last 10 years. This paper discusses the need to focus on the area of Refurbishment. The main aim of this paper is to present a contextual basis for an ongoing research study to develop a sustainable refurbishment model for hospitals. A comprehensive literature review has been employed as the methodology to discuss the current situation relative to organisational, financial, and sustainability factors. It is demonstrated that an understanding of the nature of refurbishment is required. Challenges specific to refurbishment, such as lack of as-built data and information on the state of the existing fabric and services, may have significant effects on the project in regard to time and cost. It is further demonstrated that the hospital facility has unique characteristics and Client expectations which do not affect a 'standard' commercial refurbishment.

Keywords— **National Health Service (NHS), refurbishment, sustainability, management, climate change act, adaptation**

ADAPTATION CHALLENGES FOR HEALTHCARE INFRASTRUCTURE IN A CHANGING CLIMATE.

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Purpose – The paper aims to discuss the relationships between the phenomenon of climate change, and the requirement for adaptation for healthcare infrastructure. It discusses the climate change debate, and demonstrates the linkages between climate change and sustainability in the context of healthcare infrastructure. Refurbishment is proposed as the only realistic opportunity to incorporate adaptation requirements within the existing healthcare estate. The paper proposes that a practical and user-friendly decision support model is required to facilitate the selection of 'best fit' options that also satisfies the mandatory requirement to demonstrate value for money in capital spending.
Design/methodology/approach – An extensive literature review was undertaken. An integrated approach to the dimensions of climate change, adaptation, sustainability, healthcare infrastructure, and decision-making requirements of the business case process has provided the contextual framework for the paper.
Findings – The paper identifies the critical requirement to understand the issues of adaptation and decision-making in the context of scale. It is discussed, that there is a lack of willingness to engage on healthcare and infrastructure projects, and that preference is given almost entirely to assets in regard to commercial evaluation, as opposed to service provision requirements, and civic functionality. The success of a high-level healthcare infrastructure scale adaptation strategy, is shown as being dependent upon the success of the design and adaption decisions taken at facility level by the relevant clinical and design team actors. A simplified and integrated decision-support model is required to identify key criteria and measure preferable options.
Research limitations/implications – Although beginning on a wider scale, the discussion narrows primarily, on the requirements of the UK NHS and the business case requirements of its capital investment process.
Originality/value – The study recognises importance of widening the debate and research in terms of healthcare infrastructure adaptation in the context of ongoing and future climate related events. It is shown; that a clear gap exists in this area. The paper also supports the development of a decision support prototype as the physical output of a three year PhD research project.

Keywords: Climate change, Adaptation, Healthcare infrastructure, Refurbishment, Decision-making

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