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Sustainability and Evidence-Based Design in the Healthcare Estate

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Sustainability and Evidence-Based Design in the Healthcare Estate

Springer

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ISSN 2191-530X ISSN 2191-5318 (electronic)
ISBN 978-3-642-39202-3 ISBN 978-3-642-39203-0 (eBook)
DOI 10.1007/978-3-642-39203-0
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013944521

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

Michael Phiri and Bing Chen have offered us an important and timely treatise on the potential for strategic synergy between an evidence-based design process and the growing importance of design for sustainability as found in the healthcare domain. Our paths first crossed a few years ago when I was making a presentation promoting evidence-based design to an NHS audience in Harrogate. I am pleased to have an opportunity to introduce you to their latest work.

Phiri and Chen have thoughtfully investigated the nature of the interrelationship between evidence-based architectural design for health care and designing for healthcare sustainability. They are especially interested in developing an approach that integrates evidence-based architectural design for health care and designing for sustainability in the same domain. Is there a conflict between them? Are they compatible? Must they be seen as separate? Is one subject to the other?

At its core, Phiri and Chen charge their readers to implement a strategy in design practice that couples and integrates evidence-based design and design for sustainability. They offer this advice in the expectation that implementing such a strategy offers the prospect of improved patient health outcomes and improved staff outcomes. They advocate a strategy that couples evidence-based design and sustainability to inform hospital building programmes to address the challenges of reducing healthcare spending in the face of serving ageing populations, rapidly changing technologies, and new forms of clinical practice, all the while improving quality and safety and meeting raising expectations.

My personal opinion is that evidence-based design is a process, not a product, and in fact, it is a process that may be, or already is, used effectively in design for sustainability. I have written, with a generous tip of the hat to the evidence-based medicine definition by Sackett et al., that:

> Evidence-based design is the conscientious, explicit and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project.

If one subscribes to this definition, one must be prepared to see design for sustainability as one of many possible arenas in which the use of rigorous, scientific, and relevant research offers the potential for improved decision making. It should be noted that the basis for the various standards and guidelines for sustainable design rely upon scientific, laboratory and academic references as justification for their recommendations or regulations that surely represents the very definition of an evidence-based process.

Architects and designers using an evidence-based process must carefully interpret the implications of credible research findings upon their current project, recognising that no two projects can be precisely the same, and that the interpretations may be different depending upon each unique case. The implications of research results should be applied to the unique circumstances of each individual project.

There are sections with an excellent and highly appropriate set of international case studies that offer insights into a variety of actual projects. Architects have much to learn from the works of others around the world. This makes a good starting point for further investigations. The authors have advocated for sorely needed updates to architectural education and an approach that combines evidence-based design and design for sustainability.

Phiri and Chen remind us that the worldwide healthcare system is in need of change, indeed is constantly in a state of change whether desired or not, and the authors endorse the notion that a positive and optimistic strategy for environmental interventions in response to change, or in anticipation of change, should include a process that is evident or research-based and should strive for sustainable design outcomes. In addition to design, the authors encourage the reader to consider how changes in the health and social care context suggest a need for organisational restructuring, new health policies and improved effectiveness of governance.

The authors extensively review a number of tools for design and assessment from a variety of sources. This includes guidelines, standards, norms and tools promulgated by national and international public and private organisations. Phiri and Chen see development and maintenance of technical guidance and healthcare design tools as a practical way of implementing an approach that helps couple evidence-based design and design for sustainability. I found myself particularly intrigued by the multinational comparison of guidance models that illustrated the major differences, as in the case of LEED's lack of scoring for waste and pollution which is accounted for in BREEAM and the other models. They recommend that more integrated tools are desired, and that in some cases regulations are needed to supplant voluntary suggestions.

Phiri and Chen have laudably tackled an important question for the contemporary design world and the healthcare estate. They show us that evidence-based design and sustainable design can do more than coexist—there is no conflict; they can be integrated. Recognising that sustainable design can reside comfortably within an overarching framework of making better design decisions by carefully interpreting the implications of serious research is important. This suggests the real battle is not between evidence-based design and sustainable design; perhaps the next challenge is to address the conflict between design for sustainability with the usual other suspects—the costs of sustainable initiatives, reliance on first costs over life-cycle costs, ambivalence on the part of the client, reactionary resistance to change or the lack of practical educational support for practitioners interested in sustainability.

There may be a greater potential conflict between sustainable design and medical planning for healthcare facilities. In a hospital, for example, the amount of electricity and energy use to support a 24-hour operation violates some routine principles of sustainable design. So, the sophisticated designer must make careful and thoughtful judgments about the conflicting implications found in the research. This is normal and inevitable. The research in a single domain will often present conflicts for the reader. When trying to make design decisions that relate to more than one domain, judgment comes into play. These judgments are familiar to architects and designers: prioritisation, balance, compromise, and consideration of alternatives are constantly applied in the decision-making process.

Michael Phiri and Bing Chen have produced an important document that resolves a critical issue for designers and policy makers. I hope you find it as useful as it has been for me. I look forward to the next development in their research.

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Acknowledgments

We would like to pass our thanks to the following people who have contributed to the case studies enclosed in this book brief:

New Parkland Hospital, Dallas, USA (Corgan Associates—Joe Paver and Nathan Devore)

Aarhus University Hospital (C. F. Møller Architects—Tom Hagedorn Danielsen and Anne Krull)

Houghton Le Spring Primary Care Centre (P + HS Architects—Adrian Evans and Joe Biggs)

The First People's Hospital of Shunde, Foshan District, China (HMC Architects—'Design Architects'—Raymond Pan; Foshan Shunde Architectural Design 'Institute—'Design Architects'—Linfeng Chen, Wenfeng Cai and Kunhao Liang)'

Glenside Campus Re-development Adelaide Australia (Medical Architecture—Christopher Shaw Ruairi Reeves, and Raechal Ferguson; Swanbury Penglase–David Bagshaw)

National Heart Centre, Singapore (Broadway Malyan Architects Singapore—Ian Simpson and Devendra Bagga)

We'd also like to thank people who have provided support to this research work.

Thanks are also due to the Xi'an Jiaotong-Liverpool University's Research Development Fund (RDF-11-01-05), which supported the face-to-face interviews with members of the design teams of the First People's Hospital of Shunde in Foshan District, China.

Contents

Abbreviations

AEDET	Achieving Excellence Design Evaluation Toolkit
ADB	Activity Database
AIA	American Institute of Architects
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASPECT	A Staff and Patient Environment Calibration Tool
BIM	Building Information Modelling
BSRIA	Building Services Research and Information Association
BREEAM	British Research Establishment Environment Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CIBSE	Chartered Institution of Building Services Engineers
CHP	Combined Heat and Power
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
DQI	Design Quality Indicator
EBD	Evidence-Based Design
EPC	Energy Performance Certificate
EPSRC	Engineering Physical Sciences Research Council, UK
GHBEC	Green Hospital Building Evaluation Criteria
HaCIRIC	Health and Care Infrastructure Research and Innovation Centre, UK
HEAR	Healthcare Environment Architectural Reference
HEPA	High-Efficiency Particulate Attenuation
HFBS	Healthcare Facility Planning System
LEED	Leadership in Energy and Environmental Design
NABERS	National Australian Built Environment Rating System
NEAT	National Health Service Environmental Assessment Tool
NHS	National Health Service
NDRC	National Development and Reform Commission
PFI	Private Finance Initiative
PPP	Public Private Partnership

POE	Post Occupancy Evaluation
PPE	Post Project Evaluation
SBC-ITACA	Sustainability Building Council-ITalian ACcelerometric Archive
TGBRS	TERI Green Building Rating System
WHO	World Health Organisation

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Chapter 1
Introduction

Using case studies largely and carefully drawn from UK, Europe, USA, China, Japan and Australasia, design approaches or strategies, such as design for sustainability (e.g. targets for energy efficiency, carbon neutrality and reduction in waste), evidence-based design (EBD) and post-project evaluation (PPE) have been assessed to identify policies, mechanisms and strategies that can nurture an integrated learning environment that supports innovation in health care. These definitions are not mutually exclusive. Typically on a project, an approach to sustainable design is inclusive of site evaluation, concept design, design optimisation and post-occupancy evaluation.

The discussion centres around key emerging interrelated issues: definitions of 'evidence' and of 'sustainability', centralisation versus decentralisation, public versus private sector involvement, national versus international standards, prescription versus performance standards, and regulation versus self-assurance. Considerations are made of specific procurement routes and their varying impacts on all these different issues. Rather than a 'piecemeal' approach, a 'joined-up' set-up to property and asset strategy, recognising the continuum of care across providers and institutions is advocated if, for any healthcare system, more ambitious changes and associated benefits are to be achieved. Globally, all healthcare systems, hospitals, care facilities and care homes are typically developed, designed, constructed, managed and used as separate and independent entities. This has resulted in fragmentation, duplication, redundancy, unsustainable transportation of staff and patients alike, as well as non-standardisation due to the creation of varying levels of accommodation standards. The real challenge is how to address these issues without stifling innovative practice.

Findings from the few studies that have been conducted on regulation of healthcare architecture report that most technical guidance/standards and tools are very prescriptive, focus on the measurable quantitative factors indicated largely by regulation of health and safety of the built environment, present obstacles to innovation or experimentation, being too detailed and out of date. Consequently, up to two-thirds of published information, which has gained ascendancy in the 30 years since late 1960s when the first health building notes were produced in the UK, could easily be abandoned without any detriment to the overall design quality.

M. Phiri and B. Chen, *Sustainability and Evidence-Based Design in the Healthcare Estate*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-3-642-39203-0_1,

A related issue concerns dogmatic compliance to planning standards, building regulations or design codes and the need to go beyond adhering to achieving the minimum thresholds advocated by building norms or design codes and accepting that even the most beautiful facilities that satisfy all code requirements can create numerous obstacles when designed with a lack of attention and details to patients' and staff's needs. In the UK, this provided the impetus for the development of design quality indicators in response to the realisation that the emphasis on avoiding budget and programme overruns, delivering on design components or work packages and a focus on compliance with health and safety legislation was producing architecture which although functional was bland.

In both developed and developing countries, there is need for manageable technical guidance and tools that not only foster efficiency, effectiveness and contribute towards improved outcomes but also have inexpensive maintenance and development costs. By so doing, these should then be easily kept up to date, and in line with developments, whether these are technological or are due to changes in organisational structures or clinical practices and corresponding processes.

For China, all this is particularly significant and relevant to inform and underpin China's Twelfth Five-Year Plan (2011–2015)'s aspirations for healthcare development and economic progress (China's 12th Five-Year Plan 2012). The plan indicates goals to address rising inequality and create an environment for more sustainable growth by prioritising more equitable wealth distribution, increased domestic consumption, and an improved social infrastructure with social safety nets. A key theme of the plan emphasises quality over quantity, in terms of economic growth and investments. The plan envisages the construction of 20,000 new hospitals and healthcare facilities covering six main goals for the healthcare sector:

1. Strengthen public health infrastructure, by for example, creating an e-healthcare database accessing 70 % of urban residents.
2. Strengthen the healthcare service network.
3. Develop a comprehensive medical insurance system.
4. Improve drug supply system. (hence, government funding of more than RMB 12 billion for R&D of new drugs between 2011 and 2015).
5. Reform the public hospital system, including encouraging modernisation of hospital standards and practices.
6. Support the development of Chinese medicine.

The Chinese government announced that it would spend 781.57 billion CNY ($124 billion) in the three-year plan to overhaul its healthcare system, largely aimed at providing basic healthcare services to the many millions of its people living in rural areas (Liu et al 2003). Researchers at Harvard University reported in a 2007 study that more than 80 % of healthcare services in China are delivered in cities, although 70 % of the population resides in rural areas. The three-year plan calls for the construction of 2,000 county-level hospitals and 29,000 township hospitals as well as thousands of clinics. The government pledged that every village in the sprawling country, which has a population of more than 1.3 billion, will have at least one clinic (National development and reform commission (NDRC) 2012).

These ambitious goals are essential if China is not to continue to lag behind industrialised nations on healthcare spending. According to the World Health Organisation, the Chinese government spent about 239.51 CNY ($38) per capita on health care in 2006 (the most recent data available), compared with 19,388 CNY ($3,076) in the USA (Fig. 1.1).

This Springer Brief has therefore the ultimate aim of seeking to ensure that the design, construction and management of the 20,000 new hospitals and healthcare facilities planned in the China's Twelfth Five-Year Plan are of quality, fit for purpose, affordable and manageable. Other than aiding the delivery of quality and sustainable new healthcare facilities, the Brief is concerned with ensuring attitudinal and cultural changes in order that the healthcare estate is not disregarded or taken for granted. Crucially, it should be considered as a core means and integral mechanism to achieving improved patient safety and outcomes, staff efficiency and effectiveness, increased patient, family and staff satisfaction, while accommodating today's best practices, with flexibility to adapt to the future (Fig. 1.1).

At a different scale from the massive Chinese programme is the Danish Hospital Building Programme 2008–2020 for 38 hospital projects. All the 5 regions in

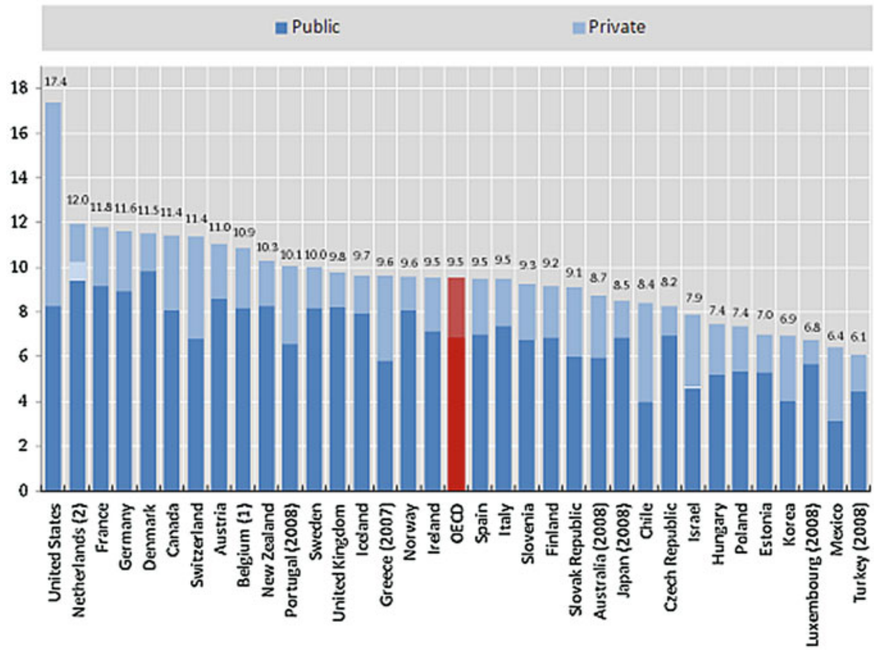

Fig. 1.1 Total health expenditure as a share of GDP 2009 (*Source* OECD health data 2011). As a share of GDP, the United States spent 17.4 % on health in 2009, 5 % points more than in the next two countries, the Netherlands and France (which allocated 12.0 and 11.8 % of their GDP on health). (Reprinted with permission March 2013 OECD (2011), ''Health expenditure in relation to GDP'', in Health at a Glance 2011: OECD Indicators, OECD publishing. http://dx.doi.org/10.1787/health_glance-2011-61-en)

Denmark [(1) Nordjylland (Aalborg), (2) Midtjylland (Viborg), (3) Syddanmak (Vejle), (4) Sjælland (Sorø) and (5) Hovedstaden (Hillerød)] adopted new hospital plans which set out the vision in accordance with a new proposed regional hospital structure. The main principles underlying the new hospital plans are as follows: (a) centralisation in terms of: (1) A reduction in the number of hospitals and (2) reduction in hospitals with highly specialised functions and with emergency departments; and (b) decentralisation in terms of: (1) strengthening the prehospital effort, (2) strengthening the role of GPs (general practitioners as gate keeper), and (3) cooperation with the local-level municipalities. A major aim for the new and modernised hospital programme is for:

- Streamlined and better planned patient pathways.
- Increased patient safety (i.e. provision of single-inpatient rooms whose aim is the reduction in hospitals-related infections).
- More effective workflows through adoption and use of new technology and health innovations.
- Fewer transports of patients, staff and goods at the specific hospital and between hospitals.
- Rationalisation of staff on 24-hour duty, laboratory and X-ray functions.
- Better use of medical equipment, scanners, laboratories and X-ray apparatus.
- Merging of administrative units and technical functions to improve efficiency and effectiveness.

Another distinguishing feature for the Danish Hospital Building Programme, which introduces some objectivity into delivery of the new or modernised hospitals, is the establishment of an expert panel consisting of 5 experts not only from Denmark, but also from neighbouring Norway and Sweden. The Economic Agreement 2008 between the government and Danish regions stated that an expert panel on investments in hospitals should be established. 'The expert panel shall review the concrete construction projects in the regions' future hospital structure and give their recommendations to the government about whether or not, the specific projects fulfil the goals and principles for quality, financing and a higher degree of productivity'. Assessment criteria adopted by the expert panel comprise of: (a) criteria for the hospital plans: gathering functions and clinical specialties on fewer hospitals, adhering to the recommendations from National Board of Health on acute medicine area, focusing on the prehospital effort and strengthening connections with other regions; and (b) criteria for the individual building projects: indicating the role of the project in a new hospital structure, identifying possible alternatives, establishing projection of needs, capacity utilisation, need for area and economy and achieving improvements in productivity and operation (6–8 % after 1 year of occupation).

The Danish Hospital Building Programme also recognises the need for learning and feedback as well as sharing knowledge while being able to develop new shared solutions. With this in mind, in 2010, the Danish regions launched a project to share knowledge with the ultimate goal of strengthening the regions' systematic shared knowledge based on central elements in hospital construction.

Where appropriate, the regions would also join together to develop shared solutions for the construction projects. Of importance, 10 milestones for sharing knowledge on hospital construction were established on: (1) joint purchase for hospital construction, (2) handling medicine, (3) production of sterile goods, (4) life-cycle costs, (5) joint tools for the building process, (6) examples of best practice standards for the different types of rooms, (7) dissemination of the examples of best practice standards, (8) transport technologies, (9) tracking equipment, apparatus, patients and staff and (10) interaction with patients supported by new technology.

Other knowledge-sharing activities include workshops on risk management and on calculating capacity; annual conference for everyone working within hospital construction within the regions and planned activities involving joint initiatives on information technology and automation in the hospital construction projects; training programme for hospital staff before moving into the new facility and follow-ups on profits on efficiency improvements. A Website (www.godtsygehusbyggeri.dk) indicates the following: the framework and terms for the building projects; status of the building projects and maps of the building processes; contact persons for the building projects; information on the knowledge-sharing project; expected time for procurements and relevant conferences and training courses.

This Brief's content is in six chapters. After an Introduction, the Chap. 2 identifies and reviews approaches and strategies advocated for the design of the healthcare built environment, in order to provide the rationale and a suitable basis for implementing design for sustainability, coupled with evidence-based design. Chapter 3 considers healthcare premises planning information, technical guidance and tools in health care, the main instrument used to aid the delivery of hospitals and other healthcare facilities. A summative rather than a comprehensive review of the healthcare planning information, healthcare facility briefing systems and tools provides an appropriate basis to examine some of the emerging issues. The review also answers the question of need for technical guidance and tools in health care, over and above the building regulations or norms applied to other building types. Healthcare planning information that includes briefing systems is needed because of the nature, uniqueness and complexity of health care to aid the identification and recording of user requirements and formulation of the client brief, the design, construction and management of the completed healthcare facility.

Chapter 4 identifies and showcases carefully selected exemplary case studies, first in the UK, EU and USA and second in China and Australasia of applying design for sustainability, coupled with EBD principles and corresponding design interventions. The aim is to elicit lessons learnt and to document the key drivers for these case study projects and the consequences of implementing these design approaches and strategies. For example, the First People's Hospital of Shunde, Foshan District, China project, is designated as a pilot sustainable hospital, allowing exploration of sustainable technologies for future hospitals. In this case, the design goal and challenge is to translate advanced Western healthcare ideas to accommodate Chinese local practices, creating an innovative healing environment.

The case study highlights some of the difficulties of wholesale importing of guidance and tools based upon policies, regulations and supporting infrastructure of the countries of origin. The need is for customisation of the guidance and tools, not only to recognise local practice and geography but also to acknowledge the limitations of the operating framework.

Chapters 5 and 6 of the Brief provide an appropriate platform for discussing emerging issues and worldwide challenges facing all the organisations that provide commission and regulate the delivery of health care and/or the accommodation in which health and social care is provided. The Brief concludes by accepting that implementing design for sustainability, coupled or integrated with evidence-based design, is developing as an emerging science, rather than EBD on its own.

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Chapter 2
A Review of Design Approaches + Strategies

Design for Sustainability

Design for sustainability is part of a bigger picture of sustainable development and a drive globally for cleaner production, ecoefficient industrial systems and life-cycle management. This approach or strategy has the potential to improve efficiencies, product quality and market opportunities (local and export) and at the same time improve environmental performance. Changing current unsustainable consumption and production patterns can benefit a lot from a strategy of design for sustainability.

Worldwide, buildings are responsible for approximately 30 % of raw material use and 40 % of energy consumption and carbon emissions. Sustainable building aims to systematically reduce these figures by focusing on future developments while at the same time provide social and economic benefits. Green design buildings minimise the destruction of natural habitats and biodiversity, reduce air and water pollution, water consumption and energy use, limit waste generation due to recycling and increase user productivity.

A healthcare mission therefore needs to have measurable goals and objectives that support sustainability and the ability of a healthcare system to thrive in its ecological, social and economic environment (Fig. 2.1).

Design for sustainability is important in health care because hospitals and other healthcare facilities have a huge impact on the geographical economy generating in some cases over 20 % of its turnover. Design quality of the built environment is vitally important not merely to the economic well-being of the nation but also to its social agenda. Health care has an ongoing capital building programme with challenges from an estate consisting largely of old stock characterised by a slow rate of replenishment and modernisation. Crucially, health care offers generic lessons for other sectors and the construction industry as a whole.

The healthcare buildings as an exemplar offer opportunities to adopt a holistic, as opposed to a piecemeal approach, to sustainability with features that address energy supply and demand and water management. Healthcare facilities are key consumers of energy, and therefore, their consideration is an imperative to meet global targets for sustainability.

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DOI: 10.1007/978-3-642-39203-0_2,

Fig. 2.1 The interrelationship between design strategy, tactics and operation (*Source* Zurb Product Designers 2012) and Thinkpad's evolution design strategy to lenovo (*Source* David Hill 2 March 2010)

Using the triple bottom line construct of people, planet and profit also provides the major connections between sustainability efforts, lean operations and adaptive spaces and how these are inherently linked to form a strong foundation for a triple bottom line. The current state of sustainability, lean application and adaptive space efforts in healthcare facilities indicates specifically how these three topics can, and are, drive the triple bottom line of people, planet and profit for healthcare organisations.

Evidence-Based Architectural Healthcare Design

Evidence-based design has become popular in healthcare architecture in an effort to improve patient and staff well-being, patient healing process, stress reduction and safety. This approach emphasises the importance of using robust evidence or credible data deriving from rigorous methods and studies in order to influence both the design process and its outcomes. Hence, the definition as 'The deliberate attempt to base design decisions on the best available research evidence… Evidence-based healthcare designs are used to create environments that are therapeutic, supportive of family involvement, efficient for staff performance, and restorative for workers under stress. An evidence-based designer, together with an informed client, makes decisions based on the best information available from research and project evaluations' (Hamilton 2003).

The term evidence-based design has been transposed from the medical world of evidence-based medicine, i.e. '…the explicit and judicious use of current best evidence in making decisions about the care of individual patients… By best available external evidence we mean clinically relevant research often from the basic sciences of medicine, but especially from the patient centred clinical research into the accuracy and precision of diagnostic tests (including the clinical examination), the power of prognostic makers, and the efficacy and safety of therapeutic rehabilitative and preventative regimens. External evidence invalidates previously accepted diagnostic tests and treatments and replaces them with new ones that are more powerful, more accurate, more efficacious, and safer… Without current best evidence, practice risks becoming rapidly out of date, to the detriment of patients… Because the randomised trial, and especially the systematic review of several randomised trials is so much likely to inform us and much less likely to mislead us, it has become the "gold standard" for judging whether a treatment does more good than harm' (Sackett et al. July 1996a). Also, '…Evidence Based Medicine requires the integration of individual clinical expertise with the best available external evidence from systematic research…' (Sackett et al. January 1996b; Sackett and Haynes 1996). In architectural healthcare design, without the centres such as UK's Cochrane Collaboration and Centre for Reviews and Dissemination which provide systematic reviews of the effects of health care, it was always going to be a challenge to the evidence up to date.

In architectural healthcare design, the idea of evidence-based practice needs to acknowledge the fundamental reality that design is about making choices whose goal is to do this on an informed basis, thereby making the decisions accountable to the best available evidence whenever possible.

Evidence-based hospital design is a new field that guides healthcare design, construction and operation. Research indicates that well-designed physical settings play an important role in helping hospitals to support patients healing and making hospitals better places for staff to work. The findings support the importance of improving a range of design characteristics or interventions, for example good acoustic environments, provision for nature distractions and daylight. The state of knowledge of evidence-based hospital design has grown rapidly in recent years. And today, we know that a building exerts a powerful force on and contributes to the delivery of health care. Studies show that natural light, quiet surroundings and scenes of nature can, among other things, reduce patients' stress and aid recovery. Evidence-based architectural healthcare design is not just about focusing on making new hospitals pretty and nice.

To successfully implement evidence-based design principles, healthcare design teams must adopt approaches that create an environment of care that incorporates streamlined processes, new technologies and nurturing design elements. This means identifying proven evidence-based strategies and corresponding interventions that would improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family and staff satisfaction while accommodating today's best practices, with flexibility to adapt to the future.

1. *Improving patient safety*: For example, through specifying slip-resistant flooring and installing large patient bathrooms that help reduce patient falls and injuries. Findings from studies confirm that infection spreads by physical contact more frequently than airborne transmission, suggesting the need for more emphasis on hand sanitation and contact isolation of patients. The provision for all single-inpatient rooms aids contact isolation and therefore reduces the risk of hospital-acquired nosocomial infections and associated hospital readmission (Emerson et al. 2012), while the use of HEPA filtration systems in patient rooms, emergency examination rooms and other zones can protect the most vulnerable patients and specifying antimicrobial flooring and specially treated fabrics or disposable curtains to reduce the spread of germs. Also, to

reduce spread of germs further, infection control officers are demanding that personal protective gear or equipment (including storage of over-gowns, masks and several sizes of gloves) be conveniently located outside each patient room or small grouping of patient rooms while more negative pressure rooms—usually two to three per a typical 28–36 bed acute care unit—be provided.

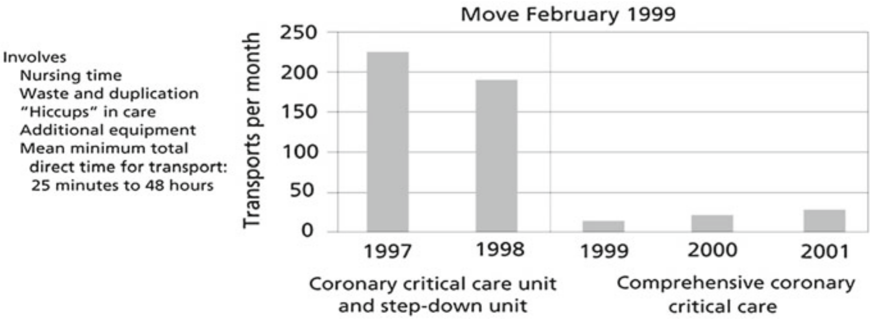
Whether by design or not, infection control strategies influence and shape patient room design. Consequently, patient room designs may be based on minimal (pillow, blankets accessible to families and the required patient wardrobe) to zero storage in the room, substituted by either covered supply carts or built-in nurse servers directly outside the room to facilitate decontamination and deep cleaning when one patient leaves and another is checked in. Less cluttered patient rooms also encourage and enable mobility and activity which aids recovery. Designs include eliminating the amount of horizontal or cleanable surfaces which could conceal germs by, for example, installing integral blinds, vista or e-glass in windows, glazing screens or view-panels in doors. Furniture and fixtures in the patient rooms are specified to ensure that contaminated materials (e.g. soiled linen, over-gowns, gloves, intravenous pumps, masks and wheel chairs) after patient use are easily removed or disposed and do not remain in the patient room longer than necessary.

Evidence from post-occupancy evaluations (POE) indicates that most patient falls occur when patients are going to and from the toilet and shower and around the bath. Designs that minimise the distance between patient bed and toilet as well as providing a means of support, such as unobstructed grab bars, therefore help reduce patient falls.

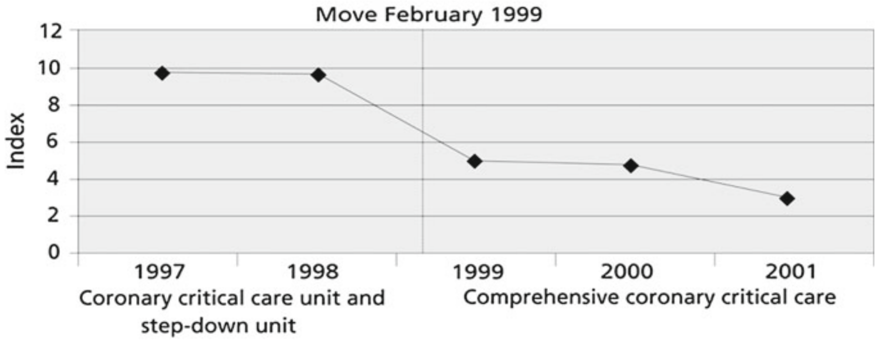
2. *Improving patient outcomes*: For example, through providing decentralised caregiver workstations between every two-patient rooms with visual access into each room, which increases capabilities for observation. Decentralisation of some supplies and equipment relative to the patient room reduces the amount of travel time the caregiver spends on fetching these supplies.

   Building acuity-adaptable patient rooms supports the position that the patient remains in the same room for the duration of their stay, and the staffing level is adjusted according to the acuity of the patient. This reduces movement or transfer of patients, results in fewer handoffs between caregiver teams (thereby limiting treatment delays and opportunity for errors) and eliminates delays for placement of patients. By bridging acuity levels from medical/surgical (acute) to intermediate (step down) to critical (intensive) care ensures that there is less need for equipment duplication and provides for fewer complications all of which decrease a patient's length of hospital stay (Hendrich et al. 2004). Acuity-adaptable patient rooms also lower staff injuries from transferring patients, while a dedicated family area in each patient room encourages family members to participate in the caregiving process, allowing continuity of care once the patient is discharged (Fig. 2.2).

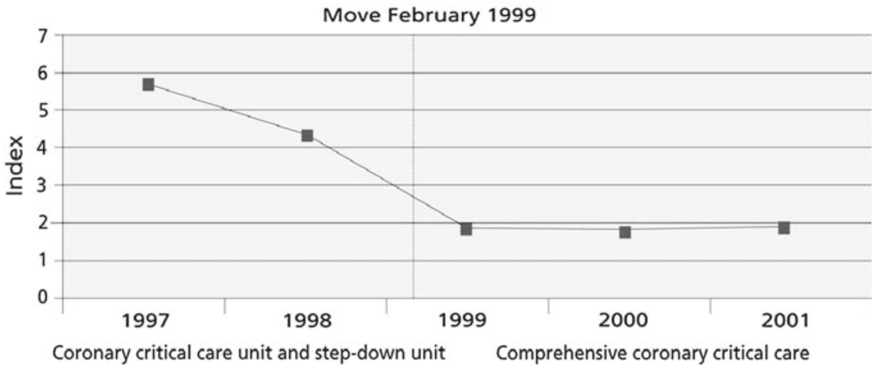
   In a study of a total of 610 consecutive patients admitted to a universal bed unit and prospectively entered into the Society of Thoracic Surgeons National



(a) Transports per month



(b) Errors/patient days



(c) Falls/patient days

Fig. 2.2 Impact of integration of acuity-adaptable rooms: monthly transfers were reduced by 90 % (**a**) with a resultant 70 % reduction in medical errors (**b**) and decrease in annual index of patient falls (**c**) (*Source* Hendrich et al. 2004) (Reprinted with copyright permission March 2013 licence number 3106940882460 from American association of critical-care nurses provided by copyright clearance center). **a** Transports per month. **b** Errors/patient days. **c** Falls/patient days

Cardiac Database, Emaminia et al. (2012) found that the universal bed patient care model allows for expedient and efficacious care as measured by decreased length of intensive care unit and length of hospital stay, improved post-operative outcomes, patient satisfaction and cost savings. Results showed decreased ventilation time, intensive care unit and hospital stay, and reduction in the incidence of atrial fibrillation and infection complications which yielded a financial benefit in the universal bed group compared with the traditional model of admission. Compared with regional centres, there was an average cost savings between $6,200 and $9,500 per patient depending on the operation. Patient care satisfaction by independent survey was in the 99th percentile.

3. *Increasing patient, family and staff satisfaction*: For example, through environmental noise control measures such as sound-absorbing finishes to reduce stress; use of 'on-stage/off-stage' design features which separate corridors and elevators for visitors and staff and in turn lessen foot traffic and, along with sound attenuation between rooms, reduce noise creating a calm peaceful healing environment (Fig. 2.3).

The size of single-inpatient rooms allows for rooming-in capability with a dedicated family area located nearest the window and away from the entrance to the room so that staff members have clear access to the patient from the hallway. Caregiver space inside the patient room is between the doorway and the patient bed for enhanced privacy for the patient because caregivers face the patient and the family when discussing care and are turned away from the door.

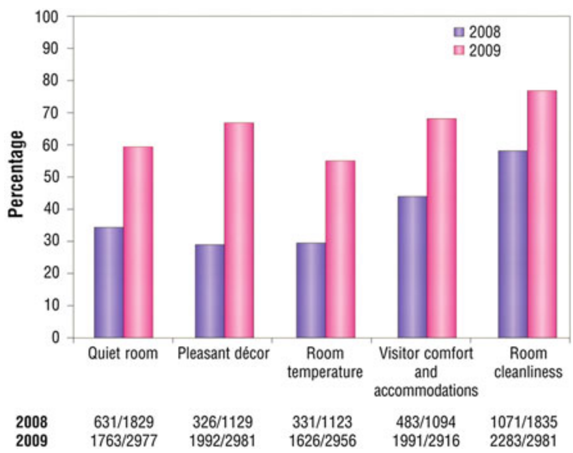


Fig. 2.3 Hospital consumer assessment of healthcare providers and systems 'always' or 'very good' scores before (April–September 2008) and after (January–October 2009) change in environment. Rating options for quiet and cleanliness were *never, sometimes, usually and always*; rating options for all other factors were *very poor, poor, fair, good and very good*. Data on the quiet and cleanliness factors were provided from January through September 2008 [*Source* Trochelman et al. (2012)] (Reprinted with copyright permission March 2013 licence number 3106940664127 from American association of critical-care nurses provided by copyright clearance center)

The integration of family areas into the medical/surgical/intermediate care patient rooms furnished with sleeper sofas, blanket and pillow cupboard storage eliminates the need for centralised family waiting rooms and ensures that the family is closer to the patient at the bedside.

Provision for individual temperature control allows patients to control the comfort level within their own room. POE found that the inability to control room lighting was dissatisfying. Soft lighting and soothing artwork installed can alleviate restlessness and provide suitable distractions that lessen dependence on medications (Diette et al. 2003).

4. *Enhancing staff and patient experience through place-making which fosters views, connection with nature*: For example, when both patient and staff rooms have large windows/doors that offer unobstructed natural views, an abundance of sunlight and access to well-designed landscaped therapeutic gardens not only provide calming and pleasant nature views, but also foster access to social support, privacy and escape from stressful clinical settings. Orientation of patient rooms to facilitate sun penetration and benefit from the medicinal properties of bright daylight while avoiding dimly lit rooms located on the north-side locations entrains circadian rhythms, enhances mood, promotes neurological health, reduces pain levels and length of hospital stays, allows taking of fewer strong analgesics and affects alertness (Walch et al. 2005; Figueiro et al. 2002; Heerwagen 1990).

   Designs that promote connection to nature on a daily basis to places with rich vegetation, flowers, large trees, water and meandering paths are beneficial to all in offering relaxation and multi-sensory enjoyment while improving moods and reducing stress (Groeneweggen et al. 2006). The biophilia hypothesis indicates that as species, human beings are still powerfully responsive to nature's forms, processes and patterns (Kellert et al. 2008; Kellert and Wilson 1993). Laboratory studies of 'green exercise' testing the effects of projected scenes on physiological and psychological outcomes of subjects on a treadmill found that all the subjects benefited similarly in physiological outcomes, but that subjects who viewed pleasant nature scenes (both rural and urban) score higher in measures of self-esteem than those viewing totally urban scenes or 'unpleasant' rural scenes with destroyed landscapes (Pretty et al. 2003, 2005). With nature always on the move, the sun, clouds, water, tree leaves, grasses, all moving on their own rhythms or with the aid of wind remind us of change, transformation and resilience, as well as of cycles of birth, death and regeneration. Recognising the variation and similarity in form and appearance of patterns of nature is themselves the basis for aesthetic appreciation.

5. *Meeting staff/patient expectations through understandable and navigable places*: For example, way-finding is intuitive ensuring 'mental maps' that make it easy to visualise the destination from the point of entry and acknowledge that straight corridors make stretcher travel easy with minimal motion waste. Buildings, streets and open spaces ought to be designed to generate an understandable layout by way of routes, informal spaces and key focal points

that provide a sense of place. The cost of an inefficient system for way-finding and navigation was estimated to be more than $448 per bed or $2,20,000 per year (Brown et al. 1997), with much of this cost involving 4500 h of hospital staff other than information staff giving directions.

A growing trend in enhancing exceptional patient experiences is the use of interactive technology to bring an unprecedented range of services and control under the patient's fingertips both inside and beyond their hospital room. The systems offer information well beyond an 'on-demand' network in a truly interactive experience that engages patients in their care providing information, which supports them on their healing journey. Through this technology, patients can submit feedback and make requests, which become part of a highly efficient clinical workflow. Access to information and medical education involves and supports them in their care.

Underlying the goal of improving patient satisfaction is the need to measure (using qualitative methods such as focus groups, interviews and surveys and quantitative analysis of data such as waiting times, number of episodes) and constantly to monitor the patients' perspective to the healthcare services. This includes identifying and determining patients' preferences and expectations to provide an appropriate basis for continuous quality improvement.

6. *Improving staff efficiency and effectiveness*: For example, through raising morale and motivation which impact on staff recruitment and retention—critical factors that militate against labour shortages in the healthcare sector. Providing same-handed rooms, which feature an identical, repeated layout, is used to promote safety and other key factors.
   a. COST—Mirrored patient rooms permit the sharing of plumbing chases or ducts in multi-storey buildings in hospitals and other healthcare facilities. The savings associated with repetitive construction due to standardisation often offset this cost.
   b. PROOF—Many studies have focused on the reduction in medical error, which is extremely multi-faceted with numerous contributing factors. Isolating the benefit of standardisation alone is impossible (Fig. 2.4).
   c. CONFUSION—The introduction of the term 'same-handed rooms' has added to the confusion and misinformation regarding the benefits of standardisation. A same-handed room does not mean the room is standardised!
   d. VARIATION—Just like you cannot be a little bit pregnant, the environment is either standard or not standard. Variation in layout resulting from many types of intrusion from the building structure, Mechanical Electrical and Plumbing Systems or the basic geometry conflicts with an attempt to standardise. Standardisation as a design driver must be declared at the beginning of the project.
   e. CHANGE—The liability of changing a long-standing paradigm such as the use of mirrored patient rooms that is deeply embedded into multiple design disciplines and construction costing models is difficult.

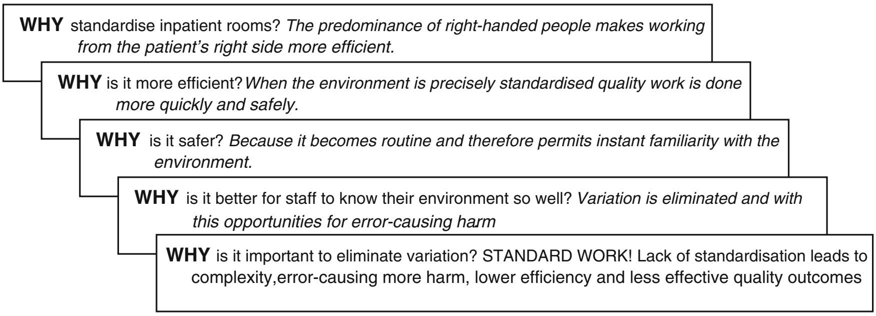


Fig. 2.4 The case for implementing standardisation and lean principles in health care is overwhelming

7. *Accommodating today's best practices, with flexibility to adapt to the future*: For example, through design of a flexible hospital incorporating modular units and standardisation provides the capacity to grow and change to meet the future medical needs of its community and the capability to adapt to changes efficiently with minimal investment. In practice, building capacity needs to meet future demand in order to anticipate growth by:

   - *Incorporating larger design elements with some unused or shelled space* that can allow immediate response to unanticipated needs until all vacant space has been put into service and a subsequent phase of additional expansion becomes necessary.
   - *Providing an unfinished cell or zone* that in the short term accommodates 'soft' brief or programme elements, such as administrative, clerical or education, in all departments but is destined for future long-term expansion of the 'hard' programme, such as the surgical core or the imaging department.
   - *Shelling entire floors* (e.g. basements or top floors) in larger project moves to accommodate growth and expansion of healthcare services can ensure that key departmental adjacencies, interdependencies, proximities and circulation patterns are maintained into the future. A building with several shelled floors can also maximise the scaled use of a specific piece of land allowing for efficient land utilisation.
   - *Planning spatial flexibility into the structural grid, floor layout configurations and into room sizes* (such as patient rooms, operating theatres, highly specialised surgeries or common areas) to enable uses for a space to change throughout the life of the rooms in order to meet new and anticipated technologies for example accommodate future MRI magnets, robotic intraoperative radiation therapy lead shielding. The spatial flexibility may be achieved by over-sizing of spaces with above the recommended clearances, for example, increasing the clear width of these rooms by 300 mm to enhance accessibility at the patient's head incorporating flexible

installation and reconfiguration of medical gases, power and low-voltage systems and space around the bed for various equipment and activities such as during cardiac arrest situations. Typically, fully adaptable rooms are then designed within the 18.6–27.9 m^2 (280–300 NSF) range with the toilet and shower room ensuite as extra.

- *Examining multiple design options in relation to the stated goals of the project and vetting the scenarios* based on an analysis of industry-wide trends, community changes in demographics, economic trends, prospective new legislation and the healthcare organisation's competitors.

Carthey et al (2011) reviewed relevant literature and project documentation for five case studies, visiting and documenting key adaptability features of each case study facility and consulting with health facility personnel where available. Findings from the review indicated that longer-term flexibility is assisted by generous site area, lower-rise hospital buildings along a horizontal circulation spine ('hospital street'), surplus building service capacity facilitating easy expansion/alteration and a consistent workable planning grid supporting a range of standardised room sizes. The study concluded that future studies are needed that evaluate the impact of high land values on site utilisation, especially in terms of future proofing multi-storey buildings, and how best to assist healthcare clients decide when 'enough' flexibility has been provided (Table 2.1).

Lu and Price (2011) saw the problem of healthcare space flexibility as that to ensure short- and long-term operational efficiency and cost effectiveness and subsequently developed potential solutions to the evidence-based design of healthcare space at the hospital department and ward level. As part of designing the high-quality healthcare space, the key parameters considered in this research were the need for multi-use and multi-functional space; flexibility; standardisation; patient safety and operational efficiency.

Barlow et al. (2009) studies of adaptability and innovation in healthcare facilities had three main conclusions. First, there are barriers in communication between designers and users, for example, communication and collaboration between the trust and special-purpose vehicles and subcontractors are often difficult and disrupted because of contractual arrangements. For the designers, there appears to be two 'clients'—the special-purpose vehicle and the traditional client, and the hospital and its users. Second, transfer of knowledge within and between projects is limited. Systematic capture of experience on PFI projects by trusts is largely absent. There is pressing need to learn from the history as well as from the experience of developing new hospitals under the PFI model. *The PFI model may have been less effective in stimulating design innovation than the system it replaced. That system involved greater coordination throughout the NHS. The lesson of all this for those wishing to nurture innovation today is that we also need to think ahead about capturing and disseminating learning*. Finally, continuous reorganisations of the NHS stifle innovative thinking and the *focus on the future*. NHS culture tends to concentrate on *fulfilling today's needs* as opposed to thinking long term. *The old model of strategic planning by the UK central government*

Table 2.1 Definitions of flexibility and its application

Focus	Managerial considerations	Functional requirement	Building system
Micro	*Operational*	*Adaptability*	*Tertiary*
	Easy to reconfigure, low impact on time and cost (e.g. furniture and interior spaces)	Ability to adapt existing space to operational changes (e.g. workplace practices)	5–19 year lifespan, no structural; implications (e.g. furniture)
	Tactical	*Convertibility*	*Secondary*
	Involves commitment of capital expenditure; changes not easy to undo (e.g. design of operating rooms, provision for interstitial floors)	Ability to convert rooms to different functions	15–50 year life span (e.g. walls and ceilings, building service capacity)
Macro	*Strategic*	*Expandability*	*Primary*
	Substantial increase in the lifetime of the infrastructure (e.g. long-term expansion plans, future conversion to other functions)	Ability to expand (or contract) the building envelope and increase/decrease capacity for specific hospital functions)	50–100 year lifespan (e.g. building shell)
Source	(de Neufville et al. 2008)	(Pati et al. 2008)	(Kendall 2007)

Source Carthey et al. (2011)

department—plus implementation by regional and area authorities—no longer applies (Table 2.2).

Lean Process Methods in Health Care

As a holistic capital healthcare project delivery approach with the objectives of maximising value and minimising waste, lean construction is an important design approach for the healthcare sector. In combination, lean health care and lean-led design are powerful tools that offer opportunities to consistently produce quality outcomes while eliminating waste. Through overcoming obstacles to standardisation, the benefits which can be realised of standard work and processes in lean manufacturing and ‘factory thinking’ are now undisputed (Fig. 2.4).

Womack et al. (1990) were the first to describe the thought process of Lean and subsequently (Womack and Jones 1996) distilled the five lean principles as follows:

1. Specify the value desired by the customer.
2. Identify the value stream for each product providing that value and challenge all of the wasted steps (generally nine out of ten) currently necessary to provide it.
3. Make the product flow continuously through the remaining value-added steps.
4. Introduce pull between all steps where continuous flow is possible.

Table 2.2 Building layers and design considerations for the intertwined and interrelated factors of adaptability and flexibility [the 6 S's from Diamond (2006) and Brand (1994)]

The 6 S's	Duration	Conditions for intermediate change	Key considerations for adaptability + flexibility
1. Site	Eternal The outer layer—site—the only truly immutable, eternal one!	Move from property assets to range of sites and building tenure to facilitate change + adaptability	*Location + accessibility* Consider locating site near public transportation routes, links to amenities and nature of car parking arrangements *Options for expansion* Consider purchase of additional land, adjacent or neighbouring land + properties, and consider scope for both horizontal and vertical expansions *Master planning* Design to accommodate future scenarios allowing for future expansion with minimal construction (future-proofed construction of walls, ceilings, building services capacity). The planning process requires some forecast of demand and life-cycle cost analysis, even though this design dilemma is a response to uncertainty *Development control plan* Design to guide development on the site
2. Structure	30–300 years but practically no more than 60 years. Resists change and adapts slowly!	Range of building types—temporary to permanent—to facilitate rapid indeterminate change	*Structural grid* Consider a modular grid system that facilitates plug-and-play system of configuring rooms, functions and a variety of building types. Suitably sized uniform building grid is applied in conjunction with a core distribution system for various building services that allows subdivision and reconfiguration in response to emerging and changing purpose and needs *Loading capacities* Design floors to handle extensive dead loads (storage) and extensive live loads (activities). Provide structural foundations to allow additional floors to be added at a later date or time. Reduce building complexity *Open building* Design to minimise conflicts between building elements (Primary Systems: life cycle: 50- to 100-year long-term investment; unchangeable) *Emergency exits* Design egress stairs and hallway widths to comply with the latest regulations and standards for several different building types *'Shell space' entire floors* (e.g. basements or top floors) to ensure that key departmental adjacencies, interdependencies, proximities and circulation patterns are maintained into the future

(continued)

Table 2.2 (continued)

The 6 S's	Duration	Conditions for intermediate change	Key considerations for adaptability + flexibility
3. Skin	20 years More easily changed	Like government, defining our appearance and how we are represented, but really just a public face for what we would currently like to project ourselves as	*Walls, doors, windows and glazing systems*: Design and standardised connections and components that facilitate prefabrication, easy assembly and disassembly *Dynamic infrastructure* Consider interstitial floors to provide acuity-adaptable medical services and technology. Moveable, demountable walls can be rapidly erected or moved solving the problem of major, costly alterations *Open building* Design to minimise conflicts between building elements (Secondary Systems: life cycle: 15- to 50-year medium-term investment; adjustable). Separate short-lived and long-lived components
4. Services	7–15 years Cannot always keep up to contain the fast-moving progression of culture within	Services are highly accessible and potentially remote from building envelope for flexibility + mobility	*Mechanical electrical + plumbing systems* Consider sustainable energy sources to reduce energy consumption and long-term costs. Also consider measures to reduce water consumption, cut out waste to meet increased durability/resilience *HVAC + Electrical Systems* Design additional capacity (20 % overcapacity for HVAC and 30 % output of electrical power) to meet increased electrical demands *Open building* Design to minimise conflicts between building elements (Tertiary Systems: life cycle: 5- to 15-year short-term investment; changeable) *Equipment* Specify standard equipment that can easily fit into different areas for flexibility in function or can easily be replaced. Where possible use portable equipment and when equipment must be fixed design for other functions in the space to maximise use *Furniture* Specify less customised furniture that can easily fit into most parts of the building, can be adapted to technical specifications (modular systems) and can be easily moved or replaced

(continued)

Table 2.2 (continued)

The 6 S's	Duration	Conditions for intermediate change	Key considerations for adaptability + flexibility
5. Space Plan	3–30 years How we rearrange stuff around us individually to be a fun or comfortable part of our lives	Increasingly significant costs—near-future technologies, unknown accessibility + mobility, spatial demand, unknown—technical equipment may get smaller, but trend towards increasing amounts	*Room design* Consider universal and acuity-adaptable patient rooms, standardised, same-handed rooms as well as standard sizes integrated with modular furniture arrangements and storage capacity to facilitate multiple uses for maximum room functionality. Design for large spaces for multiple uses (e.g. group events and activities) incorporating room dividers and moveable compartments for additional flexibility *Zoning* Separate public, diagnostic and treatment, staff functions for improved internal circulation that fosters dignity and privacy. 'On-stage/off-stage' design features can be used to separate corridors and elevators for visitors and staff. Organise clinical laboratories according to 1. highly flexible, 2. semi-flexible and 3. least flexible zones *Options for expansion* Design horizontal and vertical circulation patterns to maximise future scenarios. Consider open-ended corridors to allow buildings to expand in one or more directions. Flexible circulation routes in the form of a vertical core are also a component of modular and 'POD facility' design *Over-size spaces* with above the recommended clearances, for example, increasing the clear width of these rooms by 300 mm to enhance accessibility at the patient's head and facilitate 'plug-and-play' flexible capacity in terms of medical gases, electrical power outlets and communication and data ports *Provide an unfinished cell or zone* that in the short term accommodates 'soft' brief or programme elements, such as administrative, clerical or education, in all departments but is destined for future long-term expansion of the 'hard' or 'hot' programme, such as the surgical core, imaging department, operational theatres and intensive care units
6. Stuff	1 day–1 month Changes as fashions come and go!	Emphasis on 'shell + setting', reduction in fixed scenery with emphasis on mobility + adaptability, e.g. mobile equipment	*Multiuser, multi-use clinical workstations* Consider modular furniture, adjustable height tables and movable furniture recommended so workstations can be removed or reconfigured as technological processes change *Travel distances* Consider how much time is spent walking (gathering supplies, accessing computers, etc.) and how this can be lessened *Patient preferences and values* Obtain feedback on comfort of chairs, pillows, blankets and other supplies or equipment that can be updated for comfort and support. For example, assess chair features for patients with multiple intravenous catheters, telemetry wires or other entangling attachments *Open building* Design to minimise conflicts between building elements (Tertiary Systems: life cycle: 5- to 15-year short-term investment; changeable). Ensure tertiary systems are easy to maintain and to replace separately

5. Manage towards perfection so that the number of steps and the amount of time and information needed to serve the customer continually falls.

The Spear and Bowen (1999) study lays out four principles that show how Toyota sets up all its operations as experiments and teaches the scientific method to its workers. The first rule governs the way the workers do their work (Activities). The second governs the way they interact with one another (Connections). The third governs how production lines are constructed (Pathways). The last is how people learn to improve (Continuous Improvement). Every activity, connection and production path designed according to these rules must have built-in tests that signal problems immediately. It is the continual response to those problems that make this seemingly rigid system so flexible and adaptive to changing circumstances.

> …To understand Toyota's success, you have to unravel the paradox—you have to see that the rigid specification is the very thing that makes the flexibility and creativity possible… Whenever Toyota defines a specification, it is establishing sets of hypothesis that can then be tested. In other words, it is following the scientific method. To make changes, Toyota uses a rigorous problem-solving process that requires detailed assessment of the current state of affairs and a plan for improvement that is, in effect, and experimental test of the proposed changes. With anything less than such scientific rigour, change at Toyota would amount to little more than random trial and error—a blindfolded walk through life… (Spear and Bowen 1999).

By applying these fundamental underlying principles borrowed from industry, both lean health care and lean-led design can play an important role in healthcare reform through the great illustration of improved quality at reduced cost. Ultimately, all this means decisions made regarding standardisation in the next construction project will impact positively on safety, cost, efficiency and standard work for as long as the building remains operational.

At a Swedish paediatric accident and emergency department improvements in waiting and lead times (19–24 %) were achieved and sustained in the two years following lean-inspired changes to employee roles, staffing and scheduling, communication and coordination, expertise, workspace layout, and problem-solving in order to address problems of overcrowding and excessive waiting times (Mazzocato et al. 2012). These changes resulted in improvement because they (a) standardised work and reduced ambiguity, (b) connected people who were dependent on one another, (c) enhanced seamless, uninterrupted flow through the process, and (d) empowered staff to investigate problems and to develop countermeasures using a 'scientific method'. Contextual factors that may explain why not even greater improvement was achieved included the following: a mismatch between job tasks, licensing constraints and competence; a perception of being monitored; and discomfort with interprofessional collaboration.

When applied to healthcare planning, design and operations, Lean can improve efficiency, productivity and value. It can optimise the flow of people, goods, information and wastes at various scales from spaces, within, to and from departments to whole organisational processes and geographical healthcare

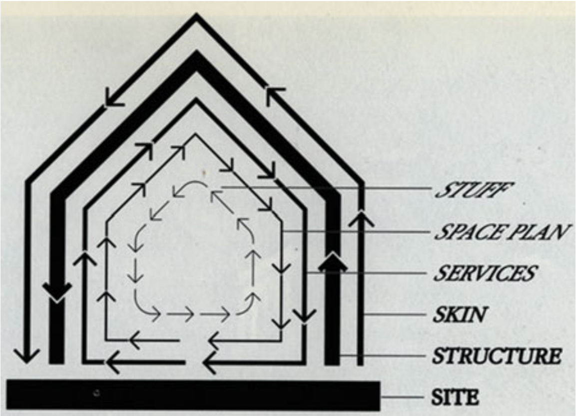


Fig. 2.5 Shearing layers of change: because of the different rates of change of its components, a building is always tearing itself apart [*Source* Brand (1994), Website Source for image http://blog.thoughtwax.com/2009/03/layers-of-change-in-ireland Accessed 13 August 2012]

economy systems. Healthcare planners, architects and construction professionals are designing modern healthcare facilities that aim to be delivered on time and within set budgets, but frequently, mistakes occur leading to obstacles to flows, healthcare service disruptions, long waiting times, lower productivity and reductions in staff and patient satisfaction.

Applying Lean to the master plan, design and operational aspects of a facility design or clinical expansion involves defining, developing and integrating safe, efficient, waste-free operational processes in order to create the most supportive, patient-focused physical environment possible (Fig. 2.5). Lean just-in-time methods of material, supplies and equipment delivery onto patient units (integrated with electronic inventory tracking systems which can predict utilisation) help reduce the amount of inventory and to build less storage on each unit leading to reduced size of building and costs. Reduced the size of equipment store rooms on patient units in turn reduces upfront equipment purchase costs. While reducing building size, lean process concepts improve clinical outcomes and operational costs.

Post-Project Evaluations + Post-Occupancy Evaluations

Post-project evaluations (PPE) (sometimes called post-mortems) represent an appraisal of a project after completion to discover lessons learnt to feed forward into future projects. These evaluations document in writing which methods worked and why; look at how tasks were completed; and determine whether the best methods were used. If the process was one that the project team found to be effective, you will want to carefully review the process so that it can be repeated in future projects. If a task was accomplished but the method could have been improved upon, you will want to list exactly what aspects of this process should be considered, analysed and revamped for future projects. You want to determine why the revised method would be more effective and what the implications would be if used on the next project. Essentially, the goal is to repeat successes and avoid failures.

POE elicit views of occupants of completed buildings. They therefore represent systematic evaluation of opinion about buildings in use, from the perspective of the people who use them. Assessments are made of how well buildings match users' needs and in the process identify ways to improve building design, performance and fitness for purpose. POE can therefore be used for many purposes, including fine-tuning new buildings, developing new facilities and managing 'problem' buildings.

Increasingly, the POE of buildings is important vehicle for the improvement of buildings and the evaluation of what makes energy-efficient and sustainable buildings. Since the 1990s, a range of POE methods have been developed and their systematic application has demonstrated a huge potential not only to reduce the financial and environmental costs and impacts of buildings, but also to improve the quality of life, comfort and productivity of building occupants. The POE will typically include a survey of user satisfaction with the chosen building, an analysis of the energy use of the building and information about the physical and managerial circumstances operating.

Preiser and Vischer (2004), Preiser (2002), Lueder (1987) and others laid the foundations for understanding both methods and purpose for POE and, to some extent the use of instrumentation in POE. Summarised by Preiser (2002) and then introduced by Zeisel (2006), the addition of physical and environmental measurements to POE has a long-standing tradition which is continuing today. The importance of instrumented field studies for the development of standards as a basis for quality improvement has grown steadily since the 1980s. This history of instrumented POE predominantly started with single-building case studies but has been progressing towards the development of portfolio databases and evaluations, as a result of government funding in the UK (Leaman and Bordass 2009), USA (Environmental Protection Agency 2008, Center for Building Performance and Diagnostics 2012), Canada (Newsham and Veitch 2012), Germany (Federal Ministry of Economics & Technology 2009) and China (Penn-Tsinghua TC Chan Centre 2012).

Typically, for example, the National Assessment Environmental Toolkit (NEAT) developed at Carnegie Mellon University by Center for Building Performance and Diagnostics (Kampschroer et al. 2009) combines portable instrumentation with questionnaires and expert walk-throughs to create robust baseline assessments of thermal, visual, acoustic and air quality in the workplace to evaluate the role of facilities in individual and organisational effectiveness. The resultant database means that a range of statistical methods can then be used to analyse the datasets, including basic descriptive statistics, two-sample t-tests, one-way ANOVA and Pearson's correlations. Data mining tools and multiple regression analysis can also be undertaken relative to each generation of research hypotheses that measure performance of work environments. Some of the results of these analyses can be captured in the six arguments for why occupants and facility managers should actively embrace instrumented POE.

Rather than broad sustainability objectives, the multi-faceted value of POE offers building occupants and resource managers opportunities to take back control of a building and its systems, identify technologies and systems that work, prove that the physical environment affects health and productivity, ensure investment takes place where it matters while guaranteeing return on that investment, recognise the importance of behaviour in environmental gains including the need for empowering the occupants and innovate to meet today's global challenges (Loftness et al. 2009).

A range of typical cost-benefit indices established for POE in hospitals include operations and management, energy and water, patient health/recovery rates, patient falls, staff health, staff turnover, absenteeism/presenteeism, bed vacancies, cost/bed, profit/bed, waste cost/benefits and medication errors.

Lorch (2001) provides a detailed description and evaluation of the Post-Occupancy Review of Buildings and their Engineering (PROBE) series of post-occupancy studies. PROBE involving observational techniques, energy survey methods and user satisfaction questionnaire is seen as showing that POE in the public domain is possible at a high level of scientific integrity without attracting litigation or technical disputation. There are a few cases in the study, but not enough, which show that the process has been of lasting benefit to the owners, users and designers of the buildings. There, however, remains the perennial issue of persuading the construction industry at large that POE is doable and worthwhile. It also seems sensible that feedback systems must not just be imposed from above but be useful and relevant to those actually working on projects.

While new building regulations call for the energy evaluation of buildings, this will be of limited value without some idea of user satisfaction. One concern is how thorough a user survey associated with a POE needs to be (Leaman and Bordass 2004; Markus 2004), but the likelihood that occupant behaviour will have a bearing on energy efficiency makes it important to include some measure of user or occupant satisfaction (Fig. 2.6).

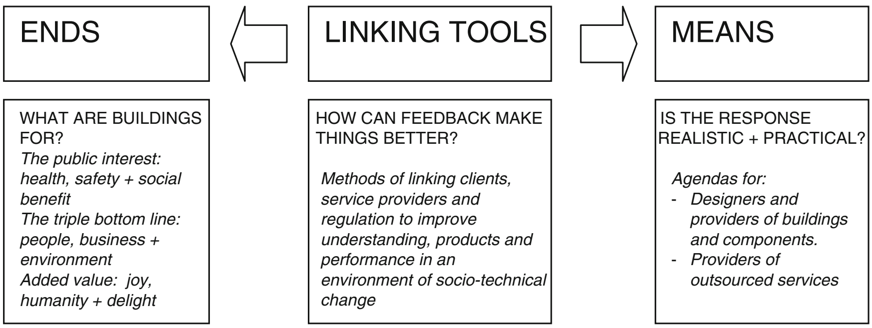


Fig. 2.6 The need for systematic feedback to improve process, product and performance

The University of Sheffield Healthcare Research Group has developed learning from experience applying feedback (LEAF) project evaluation methodology (Lawson et al. 2003; Lawson and Phiri 2003; Phiri et al. 2001). This framework provides for the evaluation of 'Process', 'Product' and 'Performance'—the three ways capital projects can fail during the three stages of the design–build–occupy cycle.

Under this framework, 'Process' includes all issues concerned with the procurement of a capital project including time and cost. Process evaluation requires reviewing how effectively the project team worked together and an appraisal of the process of commissioning, briefing, design and production, i.e. aspects concerned with measurements related to the process itself. 'Product' includes the physical materiality of the building components and systems. Product evaluation envisages examining the performance of the building, shell and fabric in understanding the elements, the systems, meeting energy targets, etc., i.e. measuring characteristics of the building. 'Performance' includes the impact of the building on the client's primary business. Performance evaluation requires reviewing the ability of the building to meet client and user goals for comfort, safety, convenience, privacy and image and business success (Fig. 2.7).

For these approaches involving post-project or POE, the healthcare sector provides well-defined targets/outcome measures with relatively short timescales that allow immediate feedback and learning from completed projects. Health care is both a suitable and a good learning environment to develop mechanisms for measuring outcome effects, tools for recording data and evaluating safety and design quality and its improvement.

A major challenge for the approach that advocates PPE is the development of a system of data collection and analysis that provides a platform for performance feedback. In practice, this means developing annual performance reports, reports cards and real-time data interfaces that aid the attainment of building performance goals.

Simulation and Analytical Modelling

Mathematical modelling is increasingly being used to as assist decision-making in a drive to achieve efficient and effective delivery of health care. Analytical modelling directly describes the relationships between the inputs and outputs of a system and solves problems using mathematical methods such as calculus or algebra. In simulation modelling, the system of interest is instead broken down into separate components that are linked to each other by means of logical relationships. The behaviour of each component is then replicated as it occurs in the real world, usually using a computer. Although analytical models can be quicker to develop, simulation modelling allows greater flexibility in representing complex and dynamic systems such as those found in health care.

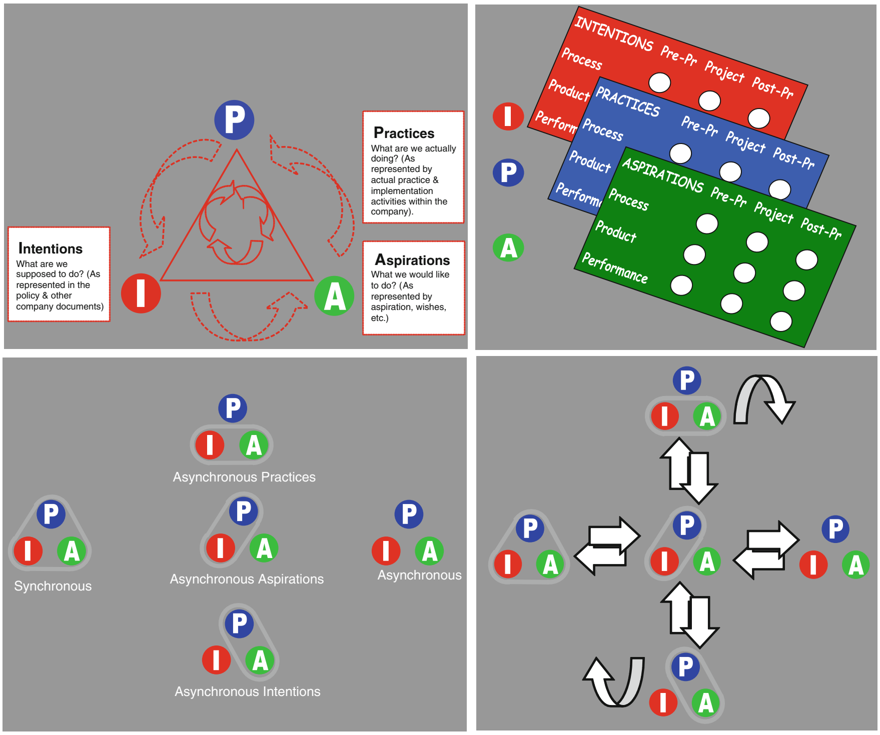


Fig. 2.7 Learning from experience applying feedback project evaluation methodology and matrix: the interrelationships between intentions, practices and aspirations underlie the state of learning in organisations [*Source* (Lawson et al. 2003; Lawson and Phiri 2003; Phiri et al. 2001]. Projects can fail in 3 ways during the 3 stages (preproject, project and post-project) of the design–build–occupy cycle: (1) Process—aspects to do with the methods of procurement, commissioning, briefing, design and construction. (2) Product—aspects to do with the actual physical characteristics of the components and systems delivered both at handover and throughout their life cycles, and the extent to which they actually meet the required specifications. (3) Performance—aspects to do with the impact of the project on the primary business of the client and user

There are many different types of simulation models and can be classified in many different ways. One such classification considers whether the model is deterministic or stochastic. A deterministic model does not contain any random, or probabilistic, components; the output is 'determined' once the input parameters have been specified. A stochastic model, however, allows for chance occurrences to influence the way in which a system operates. Models can also be considered as being continuous time or discrete event. In continuous time models, the systems being modelled are represented as changing continuously over time. In discrete event models, events are instead considered to occur at certain distinct times (XJ Technologies 2012, Bengtsson 2011) (Fig. 2.8).

Simulation modelling has been used to investigate floor space requirements for intravenous admixture compounding areas and to predict whether a redesigned

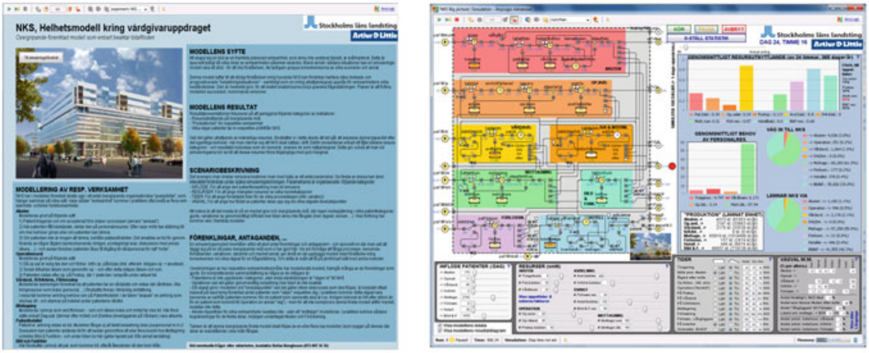


Fig. 2.8 Example of executable demonstration simulation model—'determining operational "balance" in a major hospital under construction' (*Source* Stefan Bengtsson 2011, reprinted with copyright permission from Anylogic dated 23 August 2013)

community pharmacy layout and work system could facilitate patient counselling without increasing waiting times (Lin et al. 1996).

Healthcare providers are deploying standard approaches from manufacturing and other industries to improve efficiencies and effectiveness of their organisations in a healthcare sector beset with rising costs, advanced medical treatments, expensive drugs and insurance policies, and a rapidly ageing population which is steadily driving costs upwards. In this case, efficiency and cost reduction while improving quality are becoming key themes in an industry previously only considered caring and humanitarian. Specifically, hospitals and wards are designed and reconfigured to streamline patient flow and minimise travel distance and time and delays. Key resources such as doctors, nurses and other caregivers are analysed to determine optimum staffing levels and schedules. Procedures are reviewed, bottlenecks and obstacles identified, metrics developed and equipment utilisation optimised. Developing solutions to all these tasks requires detailed analysis and experimentation—exactly the kind of disruption a busy hospital can ill afford.

Simulation modelling can support a wide range of analyses without the need of expensive and disruptive live demonstration experiments and mock-ups including hospital and ward layout planning, medical equipment usage optimisation, medical process planning and optimisation, pharmaceutical process optimisation and portfolio planning. Simulation allows the playing out of multiple scenarios quickly, easily and cheaply, minimising disruption to patient care during this simulated process and layout redesign. Simulation modelling can therefore be applied to gain deeper insight into deeper interdependent processes going on inside and around the organisation. Examples of executable demonstration models for emergency departments, HIV diffusion and syringe usage, spread of influenza, alcohol use dynamics, handling the gap between emergency and primary care, a more flexible ward concept, determining operational 'balance' in a major hospital under construction and dynamics of contagion by organisations such as XJ Technologies (2012) are a testimony to the increased use of simulation modelling.

Six Sigma Approach to Quality Improvement

Based on a quality statistic that equates to 3.4 defects per million opportunities as the target level of performance of a process, six sigma approach is increasingly being used in healthcare organisations, with the aim of improving quality by reducing defects. The core of six sigma, as a set of practices designed to improve manufacturing processes and eliminate defects, was 'born' at Motorola in the 1970s out of criticism by senior executive of Motorola's poor quality and record on defects—a defect being defined as any process output that does not meet customer specifications or that could lead to creating an output that does not meet customer specifications. Defects have serious implications on the delivery of health care—they increase costs, increase lead time and reduce quality.

As introduced at Motorola, the six sigma quality programme consists of five basic steps—define, measure, analyse, improve and control (Table 2.3).

Since its initial successful application by the Commonwealth Health Corporation, USA, in March 1998 and with cost, quality and regulatory pressures mounting within the healthcare industry, six sigma is drawing attention from hospitals seeking a better approach to reducing costs, improving quality and achieving long-term results. In this application, throughput for the radiology department improved by 33 %, while costs per radiology procedure decreased by 21.5 %. Subsequently, an investment in six sigma at the beginning of 2002 of US$900,000 produced in excess of U$2.5 million cost savings (Van den Heuvel et al. 2005). When six sigma emphasising efficiency, was implemented integrated within the ISO 9001:2000 quality management system at The Red Cross Hill Hospital Beverwijk, Netherlands, the 384-bed, medium-sized General Hospital produced €1.2 million in annual cost savings (Van den Heuvel et al. 2005). The

Table 2.3 Six sigma five-step improvement method

Six sigma five-step improvement method	
1. Define	Project identification
	Project proposal
	Project selection
2. Measure	1. Select internal critical to quality
	2. Operationalise the critical to quality
	3. Validate measuring procedure
3. Analyse	4. Determine process performance
	5. Determine project goals
	6. Identify potential influence factors
4. Improve	7. Select most important influence factors
	8. Establish relationship between critical to quality and influence factors
	9. Design improvement actions
5. Control	10. Adjust quality control system
	11. Determine new process performance
	12. Close the project

Source van den Heuvel et al. (2006, p. 395) integration was advantageous because both six sigma and ISO 9001:2000 quality management system focus on processes that are client-oriented and data driven.

Van den Heuvel et al. (2006) study shows three examples of successful projects implemented at the hospital using six sigma. Designing a new admission process for the operating rooms, optimising the use of operating rooms (September 2003–July 2004) resulted in an average starting time 9 min earlier, making it possible to operate on an additional 400 patients a year to achieve a net savings of >$273,000. By switching to oral administration, and reducing the number of patients receiving intravenous antibiotics (September 2002–May 2003) yielded an annual cost savings, based on medication costs alone of >$75,000. Reducing delivery room length of hospital stay after delivery (March 2004–December 2004) from 11.9 to 3.4 h yielded an annual cost savings of $68,000.

The six sigma approach can therefore be used for designing new hospital facilities and reconfiguring existing ones by considering the flow of patients and goods for facility planning and layout of operating rooms, laboratories and waiting rooms including analysing factors such as travel time, throughput, as well as convenient locations for patients, staff and visitors.

Conclusions from a Review of Design Strategies

The review of design strategies has indicated several underlying categories reflected in the drive for design quality, sustainability, compliance and efficiency.

Leveraging any capital investment to the extent possible to support long-term operational efficiency is essential and desirable because on an annual basis, the cost of hospital operations is approximately 10 times higher than all capital investment programmes.

Lean as a business strategy is used to improve quality and service, eliminate waste, reduce time and costs and enhance overall organisational effectiveness. The primary reasons to implement lean process concepts in health care are mainly internal, including reducing cost, improving profit margins, improving utilisation of facility/plant and maintaining competitive advantage.

Six sigma a process-focused strategy and methodology for business improvement can be used to improve care processes, eliminate waste, reduce costs and enhance patient satisfaction.

Simulation modelling is one method of evaluating examples of clinical practice to assess the impact that the built environment has on the care process. For example, common challenges faced by the majority of A&E departments include the following: long waits for patients; violence towards staff; criminal behaviour and damage to property; lack of privacy and dignity for patients; difficulty for patients and their companions in finding their way around the department. While it can often be the case that good care can be provided despite the weaknesses in the design of the facility, it is also the case that a well-designed facility can help to enhance and support patient care.

Despite all the studies to date, the ongoing challenge is building the business case for high-performance buildings and for POEs to find robust evidence of the effects of

1. Access to windows, views, daylight and natural ventilation on individual productivity, health, and satisfaction and energy use. Conversely, the impact of a deep section with sealed buildings on energy and health costs compared to thin section with openable windows.
2. Acoustic distractions, including general noise levels and speech intelligibility on individual productivity. Conversely, the impact of the level of workspace enclosure on individual productivity and employee turnover rates.
3. Thermal and indoor air quality complaints on work time lost, facility management costs and energy waste.

PPE are important to learn lessons from the past, to promote systematic capture of experience and to ensure that transfer of knowledge within and between projects is facilitated and not limited.

Crucially, evidence-based design is an emerging science vital for healthcare providers to achieve excellence and improved staff and patient outcomes (Cama 2009, FMET 2009, Hamilton and Shepley 2009, Hamilton and Watkins 2009, McCullough 2009, Hamilton 2006, 2008). Its goal is to address deficiencies in the healthcare delivery system, for example, recognising patients' preferences, values and needs (patient centredness rather than a professionally driven system), under-utilisation or over-utilisation of assets and services (ineffectiveness), non-standardised patient rooms (inefficient), untimeliness of care due to the size, shape and location of patient units within a cognitively comprehensible layout, and health inequalities due to poor or lack of planning for current and projected population demographics and their needs (equity). Evidence-based healthcare design is therefore about convincing decision-makers to invest time, money and other resources to build better hospitals, healthcare and social care facilities and to realise the resultant strategic business benefits. Evidence-based design mirrors and has parallels with evidence-based medicine whose goal is to make decisions accountable to the best available evidence whenever possible.

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Chapter 3
A Review of Healthcare Technical Guidance/Standards, Norms and Tools

Introduction to the Research Context

Healthcare planning information that includes briefing systems is essential because of the nature, uniqueness and complexity of health care to aid the identification and recording of user requirements and formulation of the client brief, the design, construction and management of the completed healthcare facility. Even when guidance and tools have been developed specifically for the whole construction industry, there has always been a case for customisation of this technical guidance and tools for the healthcare sector.

The building information modelling (BIM) has raised this very point that there should be a BIM Healthcare. BIM Healthcare would, for example, introduce a central shared library of three-dimensional healthcare graphics in simple format that facilitates updates, rationalises coding including use of several codes together (e.g. wash hand basin/pendant/bed heads), interfaces with the wider industry (e.g. stable Activity Database (ADB)/Revit software or sockets/desks/chairs level) to meet the need in accommodation for a wide variety and diverse healthcare activities (acute trauma, mental health, maternity, paediatrics, elderly and others). Healthcare facilities in turn play a vital role in shaping and influencing the delivery of health care. Many advances in cutting-edge clinical and medical research have to a large extent relied on high-quality research environments within hospital settings. Healthcare projects can also contribute significantly to regional development, both in economic and in social terms. They can help local businesses, boost local employment, widen the local skills base, improve population health and strengthen social cohesion.

The approach advocated in this brief is that design quality standards and tools exemplified by Design Quality Indicator (DQI), *Achieving Excellence Design Evaluation Toolkit* (AEDET), *A Staff and Patient Environment Calibration Tool* (ASPECT) should not be seen as competitive or divorced from but as complementary to building environmental assessment methods typically exemplified by *British Research Establishment Environment Assessment Method* (BREEAM), *Leadership in Energy and Environmental Design* (LEED™), *Deutsche Gesellschaft für Nachhaltiges Bauen* (DGNB) and Comprehensive Assessment System

M. Phiri and B. Chen, *Sustainability and Evidence-Based Design in the Healthcare Estate*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-3-642-39203-0_3,

for Built Environment Efficiency (CASBEE). Guidance and tools provide an opportunity to increase value before the cost of change rise too high across the Design-Build cycle (Fig. 3.1).

With this approach, what we see is a continued and widening separation between healthcare architecture as the pursuit of aesthetic endeavour related to the design quality agenda from building as the crafting and construction of the built environment focusing on compliance with regulations or design codes. McGlynn and Murrain (1994) describe this as the schism between technical characteristics and attributes of buildings and architecture as a form of artistic expression and endeavour.

Environment Assessment Method and Tools in Health Care

Since 1990, and the first release of the Building Research Establishment Environmental Assessment Method (BREEAM), the field of building environmental assessment has matured relatively quickly as indicated by a rapid increase in the number of building environmental assessment methods in use worldwide, for example BREEAM—UK, LEED®—USA, Germany—DGNB, CASBEE—Japan, NABERS—Australia, TGBRS—India to mention but a few that have mushroomed around the world (Fig. 3.2). UK BREEAM and the US LEED™ are the basis of the majority of the building assessment methods introduced in different countries around the world.

These multi-criteria building environmental assessment methods rate and rank buildings and groups of buildings based on their environmental performance comparing similar buildings, typical construction practices and ultimate goals. Typically, a building assessment system is therefore composed of a checklist of items organised into themes, for example energy, water, and siting, planting, and indoor environmental quality. In most systems, each item is assigned a point value, and users must then accrue a certain number of points in each theme. Users typically pay to use such a system in return for market recognition, a certificate or an award, promotional opportunities, and compliance with green building policies

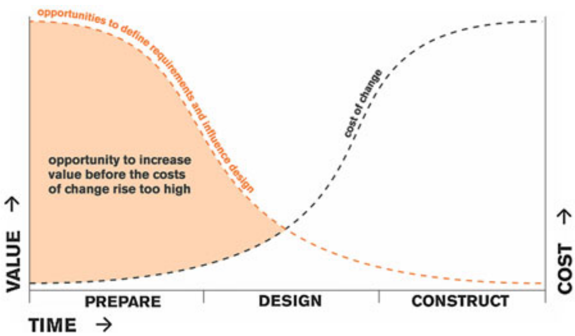

Fig. 3.1 Guidance and tools provide an opportunity to increase value before the cost of change rise too high

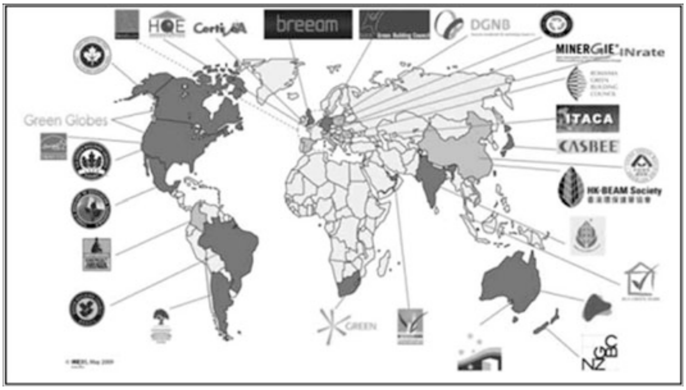

Fig. 3.2 Since 1990, the field of building environmental assessment has matured relatively quickly as indicated by a rapid increase in the number of building environmental assessment methods in use worldwide. Despite the large and rapid diffusion of these systems, there is room for improvement, for example the need to improve the communicability of assessment systems and to encourage an inclusive approach which takes into account externalities, long-term (or life cycle) effects, economic and social aspects without increasing the complexity of the assessment systems (Reprinted with permission Copyright Berardi 2011a, b)

(Brochner et al 1999, Retzlaff 2010). Through this, the multi-criteria building environmental assessment methods have largely formed the basis of most green building policies and programs or solutions to environmental problems such as energy and water usage, storm water management and greenhouse gas emissions. In so doing, they have also contributed to raising higher environmental expectations and to directly and indirectly influencing the actual performance of buildings. Cole (2011) report that the impact of these methods has been to give focus to green building practice, enable a comprehensive description of building performance and to aid the reshaping of the design process.

However, for these building environmental assessment methods, the shift from an original base in green building to sustainable building and other requirements is challenging leading researchers to evaluate their approach, objectivity and evidence base. Haapio and Viitaniemi (2008) found that making a comparison of these methods and tools is difficult if not impossible. For example, the tools are designed for assessing different types of buildings, emphasise different phases of the life cycle and in addition to environmental aspects, sustainable building includes economic and social aspects. Consequently, researchers' criticisms of the focus on energy and environmental factors have produced proposals that the systems evolve with a holistic sustainability emphasis integrating environmental, economic and social issues (Hill and Bowen 1997; Cooper 1999; Cole 2005; Lutzendorf and Lorenz 2006; Kaatz et al. 2006; Turner 2006), apply a wider range of natural resources criteria beyond the building level to include characteristics such as siting, transportation, urban design and water usage (Olgyay and Herdt 2004) as well as incorporate life cycle analysis to account for the temporal aspects of buildings (Zhang et al. 2006), for example adopting a 'whole-life' strategy that includes resource use and waste minimisation over the complete life of a building. This means gathering evidence of life cycle analysis and costing approaches which take into account predicted resource use during the successive maintenance cycles and subsequent deconstruction for reusing or recycling both the building and its components. Within the building assessment systems, the criticisms of the assignment of point values to the individual items as largely subjective (Bowyer 2007) have led to a call for an objective evidence base.

Building ratings systems have also been undermined by certain practices, for instance, "points chasing"—a process of seeking the greatest number of points under the assessment systems for the least cost, regardless of environmental benefit. For example, the LEED™ system for New Construction (version 2.2) awards one point for reusing most of an existing building (which can be very costly) and one point for using low-emission point (which is much less expensive).

Increasingly, systems are also required that are aligned with local building regulations or norms and codes of practice something which could be seen as instrumental in the prolific development of systems for different national governments. This is supported by research which has concluded that the regional and local systems are more useful and appropriate to local conditions, traditions and goals (Todd and Geissler 1999; Kohler 1999) and facilitate broader participation in the assessment process by a range of stakeholders (Kaatz et al. 2005). The form, scope, status of updates and nature of regulations in different countries are, however, an important consideration and have a bearing in terms of their alignment with building assessment methods. As with the review of building ratings systems, the cross-comparison of regulations such as that conducted in (1998) by Institute of Building Control of some 15 countries (including Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Norway, Sweden and UK) is hampered by available published information exacerbated by language barriers and by the diversity of standards, range of issues, requirements and innate differences in approaches. Confidentiality of issues about consultation process and implied value is a major obstacle to data collection, analysis and interpretation. Nonetheless, the review compared information on several requirements:

1. Mechanical resistance and structural stability.
2. Safety in case of fire.
3. Hygiene, health and the environment.
4. Safety in use (excluding access).
5. Protection against noise.
6. Energy economy and heat retention.
7. Access and facilities for the disabled.

Related to the issue of voluntary and regulatory compliance concerns how building regulations are actually implemented in practice with countries differing in their emphasis. Some countries (UK, US, Canada, Australia and New Zealand) do not have any substantive environmental requirements in their building regulations, whereas in other countries, the environment is either deemed to be of low importance or is left to other legislation and initiatives to deal with.

A comparison of BREEAM, LEED®, CASBEE, GBTool, Green Globe® and the Italian SBC-ITACA found that the multi-criteria systems rely on site, water use, transport energy and energy use data emphasising energy efficiency as the most important category (Berardi 2011a, b) (Table 3.1, Fig. 3.3). These systems focus on environmental aspects rather than economic and social factors. Not only are weightings given each criterion generally inexplicit the criteria do not overlap or align perfectly, and in some cases, the choice of criteria to gain credits has an unscientific basis. There is also a lack of life cycle perspective. Also, calculations behind the ratings are not transparent or understandable. Equally caution is necessary as regards software tools that unpin the environmental impact assessment so as to take into account that different assumptions and boundary condition can lead to widely differing results and conclusions. Furthermore, system structures for the rating systems are not always easily accessible, suggesting that ratings for these systems may well be based upon precepts that do not hold true in achieving sustainability (Table 3.1).

In Fenner and Ryce's (2008a, b) comparative analysis of the two most popular rating systems (UK BREEAM and the US LEED™ as developed by the Canada Green Building Council) on a building found that while the credits achieved were more equally distributed in the LEED™ Canada assessment than under BREEAM, the building scored well under both systems. Categories achieving the highest percentage credits under both tools were *water, energy and occupant health*. The study concludes that, while the two assessment rating systems may differ in name, applications style and ranking mechanisms, the tools are more similar than dissimilar and provide broadly comparable assessments (Fig. 3.3).

An earlier review of sustainable building rating systems by Fowler and Rauch (2006) provided a more comprehensive comparative analysis based on

Table 3.1 A comparison of BREEAM, LEED®, CASBEE, GBTool, Green Globe® and the Italian SBC-ITACA found the multi-criteria systems rely on site, water use, transport, energy and energy use data (Reprinted with permission Copyright Berardi 2011a, b)

	LEED Points	LEED (%)	BREEAM (%)	CASBEE (%)	SBTool (%)	Green Globes (%)	SBC-ITACA (%)	Media
Sustainable site	14	20	15.0	15	12.5	11.5	5	13.2
Energy efficiency	17	25	25.0	20	21.0	36	26	25.4
Water efficiency	5	7	5.0	2	0.0	10	9	5.5
Material and resources	13	19	10.0	13	0.0	10	17	11.5
IEQ	15	22	15.0	20	16.6	20	13	17.7
Waste and pollution		0	15.0	15	16.6	7.5	18	12.0
Others (econ-inno)	5	7	15.0	15	33.4	5	12	14.6
	69	**100**	**100.0**	**100**	**100.1**	**100**	**100**	**100.0**

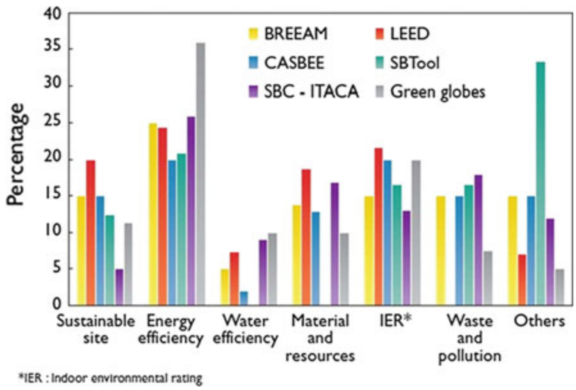

Fig. 3.3 A comparison of BREEAM, LEED®, CASBEE, GBTool, Green Globe® and the Italian SBC-ITACA found the multi-criteria systems rely on site, water use, transport, energy and energy use data. Percentages of the weights assigned by six sustainable rating systems for seven categories of sustainability indicate energy efficiency as the most important category. An 'Others' category has been created for criteria that do not fit neatly into the other six categories, e.g., management and innovation (Reprinted with permission Copyright Beradi 2011a, b)

1. Applicability (type of projects, i.e., new construction, major renovations, tenant build-out and operations and maintenance and type of buildings, i.e., office buildings, courthouses and border stations) (Fig. 3.4),
2. Extent of development (system management, i.e., government, private industry or non-governmental organisations, nature of development, funding or management arrangements and development approach, i.e., consensus-based, life cycle analysis and basis in expert opinion) (Figs. 3.5, 3.6),
3. Usability (cost, ease of use, product support, openness of operations and transparency) (Fig. 3.7),
4. System maturity (in terms of system age—when developed, first used and first available for public use and when the most recent revision was completed; number of buildings participating and completed the process for denotation as a Green Building; and stability of the system as indicated by processes that allow for full implementation—development, testing, review process, system for upgrades, process for modifications and expected frequency of modifications) (Fig. 3.8),
5. Technical content (relevance to sustainability, thoroughness and mechanism used as baseline for benchmarking specifically site, energy, water, environmental products, indoor environment quality, operational + maintenance practices and other) (Fig. 3.9),
6. Measurability (measurement comparison, standardisation + quantification) (Fig. 3.10),
7. Verification (documentation, certification/verification process) (Fig. 3.11),
8. Communicability (clarity, versatility and comparability) (Figs. 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13).

Despite the foundation of the Sustainable Building Alliance, established in 2009 to provide common evaluation categories and to improve system

	APPLICABILITY (Type of Projects and Buildings)						
	Typeof Projects				**Types of Buildings**		
	New Construction	Major Renovations	Tenant Build-out	Operations & Maintenance	Office Buildings	Courthouses	Border Stations
BREEAM	√	√	-	√	√	√	√
CASBEE	√	√	-	√	√	√	√
GBTool	√	√	-	Φ	√	√	√
Green Globes US	√	Φ	Φ	Φ	√	√	√
LEED	√	√	√	√	√	√	√

Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion;
√ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable.

Fig. 3.4 Applicability (type projects and buildings) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	EXTENT OF DEVELOPMENT (System Management and Development Approach)					
	System Management			**Development Approach**		
	Government	Private Industry	Non-Governmental Organisations	Consensus based	Life Cycle Analysis	Expert Opinion Basis
BREEAM		√	√			
CASBEE	√ /-	√	√	√	√ /-	√
GBTool	√	-	√	√	√	√
Green Globes US	√ /-	√	√	Φ	√ /-	√
LEED	√	√	√	√	Φ	√

Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion;
√ /- = Meets Criterion with Exception(s); (Blank)= Information Unknown; N/A = Not Applicable

Fig. 3.5 Extent of development (system management and development approach) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	USABILITY (Cost, Ease of Use + Product Support)							
	Cost			**Product Support**				
	Project Registration	Certification Fees	Time to Complete Application	Case Studies	Record of Inquiries	FAQ	Training Available	Available in English
BREEAM		$1290 each stage		--		-		√
CASBEE	$0	$3570-$4500	3-7days	√	√ /-	√ /-	√	√ /-
GBTool	N/A	N/A		√	-	-	-	√
Green Globes US	$500	Average $4000	5-7days	√	-	√	√ /-	√
LEED	$450	$1250 - $17500	7 weeks	√	√	√	√	√

Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion;
√ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable

Fig. 3.6 Usability (cost, ease of use and product support) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	USABILITY (Openness of Operations and Transparency)		
	Openness of Operations	**Transparency of Rating System**	
	Membership Numbers	**How much information is available publicly?**	**Availability of Information that is not on-line (How to obtain it?)**
BREEAM		Assessment Prediction Checklists	Email Address
CASBEE	√	Rating System and Manuals	Email Help Desk
GBTool	34+ Countries	All Materials	-
Green Globes US	31 Sponsor/Paying Organisations 5700 Non-paying Individuals	Rating System, Webcast, Test Drive and FAQs	Contact Form and Email Address
LEED	>6000 paying organisations	Rating System , Checklist, Credit Interpretation, Application Guides and FAQs	Email Help Desk Local/Regional US-General Building Council Chapters

Key: √ = Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion;
√ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable.

Fig. 3.7 Usability (openness of operations and transparency) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	SYSTEM MATURITY (System Age, Number of Buildings + Stability of the System)						
	System Age			**Number of Buildings**		**Stability of the System**	
	Initiated	**Availability for Use**	**Recent Revision**	**Enrolled**	**Completed**	**Testing & Development**	**System for Revisions**
BREEAM	1990	1990	2005		600+	√	√
CASBEE	2001	2002	2005		7	√	√ /-
GBTool	1996	1998	2005			√	√
Green Globes US	2004	2005	2006	63	4	Φ	Φ
LEED	1998	1998	2005	>3400	>400	√	√
Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable							

Fig. 3.8 System maturity (system age, number of buildings + stability of the system) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	TECHNICAL CONTENT (site, energy, water, products, Indoor Environment Quality, operational + maintenance practices and other)						
	Optimise Site Potential	**Optimise Energy Use**	**Protect + Conserve Water**	**Use Environmentally Preferable Products**	**Enhance Indoor Environment Quality**	**Optimise Operational + Maintenance Practices**	**Other**
BREEAM	15%	25%	5%	10%	15%	15%	15%
CASBEE	15%	20%	2%	13%	20%	15%	15%
GBTool	15% 12.5%	25% 20.8%			15% 16.7%	15% 16.6%	30% 33.4%
Green Globes US	11.5%	36%	10%	10%	20%		12.5%
LEED	20%	25%	7%	19%	22%		7%
Key: √ = Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable							

Fig. 3.9 Technical content (site, energy, water, products, indoor environment quality, operational + maintenance practices and other) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	MEASURABILITY (In terms of Measurement Comparison, Standardisation + Quantification)			
	Measurement Comparison		**Standardisation**	**Quantification**
	Benchmark	**Checklist**	**Established Collection Procedur**	**Numeric Measurements**
BREEAM	-	√		√
CASBEE	√		√	√
GBTool	√	-	√	√ /-
Green Globes US	√	√	√ /-	√
LEED	√	√	√	√
Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable.				

Fig. 3.10 Measurability (measurement comparison, standardisation and quantification) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

comparability, the above differences between rating systems still persist. It is unhelpful that the Sustainable Building Alliance's core metrics published in 2009 to show a commitment in sustainable buildings indicate a limited common set of six indicators (primary energy, water, carbon emissions, waste, indoor air quality and thermal comfort) perpetuating the issue of excluding social and economic factors. Notwithstanding this, a common metrics framework provides a benchmark against which each of the increasing diverse number of over 600 rating systems can be measured. This greatly enhances and facilitates comparability of results. Bringing together operators of building rating tools and certification, standard

	VERIFICATION (Documentation and Certification/Verification Process)				
	Documentation		Certification/Verification Process for verifying design practices		
	Type	At What Stages of the Project?	Level of Detail of Checking	Third Party	Assessor Qualification
BREEAM			Detailed Assessment of Documentary Evidence	√	Trained and Licensed by BRE
CASBEE	On-line Excel Spreadsheet	Preliminary Design, Execution Design + Completion	Depends on the Assessment Tools Used Document Review is Required	√	Trained and must pass an Assessor Examination. Must be a First Class Architect to Qualify.
GBTool	On-line Excel Spreadsheet	After Design is Complete	N/A	-	N/A
Green Globes US	On-line Tool	Concept Design, Construction Documentation & Site Inspection	Review of Documentation and Site Inspection	√	Φ
LEED	On-line and/or Hard Copy	Design Review & Construction Review	Administrative and Credit Audit	√	Trained and must pass an Assessor Examination.
Key: √ =Does Meet Criterion ; Φ = Under Development; - = Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable.					

Fig. 3.11 Verification (documentation and certification/verification process) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	COMMUNICABILITY (Clarity + Versatility)			
	Clarity			Versatility
	Well-defined	Results Easily Communicated	Process & Rating System Information Clearly Understood	Basis for Development
BREEAM	√	√	-	12
CASBEE	√	√	√ /-	1
GBTool	√	-	-	5
Green Globes US	√ /-	√	Φ	0
LEED	√	√	√	10
Key: √ =Does Meet Criterion; Φ = Under Development; - = Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable.				

Fig. 3.12 Communicability (clarity and versatility) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

	COMMUNICABILITY (Comparabilityover varying building types, locations, years or different sustainable design characteristics)	
	Results Representation	Result Product
BREEAM	Pass (25%), Good (40%), Very Good (55%), Excellent(70%) , Outstanding 85%)	Certificate
CASBEE	"Spider-web" Diagram, Histograms and Building Energy Efficiency Graph	Certificate and Website-Published Results
GBTool	Range of Detailed and Broad Histograms	N/A
Green Globes US	One to Four Globes (1=35-54%, 2=55-69%, 3=70-84% and 4=+85%)	Plaque, Report and Case Study
LEED	Certified (40%), Silver (50%), Gold (60%), Platinum (80%)	Award Letter, Certificate and Plaque.
Key: √ =Does Meet Criterion; Φ = Under Development; -= Does not Meet Criterion; √ /- = Meets Criterion with Exception(s); (Blank) = Information Unknown; N/A = Not Applicable		

Fig. 3.13 Communicability (comparability over varying building types, locations, years or different sustainable design characteristics) of sustainable building rating systems (*Source* Fowler and Rauch 2006)

setting organisations, national building research centres, and key property industry stakeholders Sustainable Building Alliance may accelerate the adoption of sustainable building practices through the promotion of shared indicators for building performance assessment and rating.

In health care, the proliferation of guidelines, rating systems, codes and standards, for example in USA—Green Globes® CIEB for Health Care, LEED®-HC, 2014 Guidelines for Design and Construction for Health Care Facilities®, the Senior Living Sustainability Guide®, ASHRAE 189.2 Design, Construction and Operation of Sustainable High Performance Health Care Facilities, and the International Green Code, is a development which is overwhelming for both professionals and novices alike. The pressing need here is therefore for some clarity. A complication is that compared with some healthcare guidance and codes sustainable rating systems are, generally, voluntary standards whose adoption is partially motivated by signaling factors.

Other than resolving the issue of system comparability, one major conclusion from the comparison of rating methods is the need for a system of data collection and analysis that provides a platform for performance feedback based upon a more holistic qualitative whole-life method of assessment. In practice, this means developing standardised annual performance reports, producing both report cards and real-time data interfaces that aid the attainment of building performance goals. Rating systems must go beyond the routine credits (site, transportation, water, heat island effect, and energy and atmosphere not only to consider life cycle perspective but also building-integrated renewables. There is growing evidence that as operational energy is decarbonised the urgent need is for future proofing of today's buildings by considering the impact of embodied energy.

The application of ratings systems readily provides data which can overtime be analysed for trends, characteristics of assessed buildings, lessons learnt and effectiveness of the environment assessment in delivering sustainability objectives. This approach is evident in studies such as Berardi (2011a, b) and in the development of the database of all LEED™-assessed buildings by US Green Buildings Council.

British Research Establishment Environment Assessment Method

BREEAM for healthcare buildings was commissioned by the UK Department of Health and Welsh Health Estates, replacing National Health Service Environmental Assessment Tool (NEAT) as the preferred environmental assessment method and certification scheme for healthcare buildings in the UK. Since 1 July 2008, the UK Department of Health requires all new builds to achieve an 'Excellent' rating and all refurbishments a 'Very Good' rating under BREEAM Healthcare 2008 during the outline and full business case for a capital scheme.

BREEAM Healthcare tool represents an important government strategy for meeting the challenges posed by the sustainability agenda, the need for improved environmental performance of NHS buildings as well as meeting its targets for energy use, generation of energy from renewables and waste management.

The BREEAM scheme for healthcare buildings is used to assess at both the design and post-construction stages of their life cycle healthcare developments of teaching/specialist hospitals, general acute hospitals, community and mental health hospitals, general practice surgeries, health centres and clinics. The 10 evaluation categories are as follows:

1. Management: Overall management policy, commissioning site management and procedural issues.
2. Energy use: Operational energy and carbon dioxide (CO_2) issues.
3. Health and wellbeing: Indoor and external issues affecting health and wellbeing.
4. Pollution: Air and water pollution issues.
5. Transport: Transport-related CO_2 and location-related factors.
6. Land use: Greenfield and brownfield sites.
7. Ecology: Ecological value conservation and enhancement of the site.
8. Materials: Environmental implication of building materials including life cycle impacts.
9. Water: Consumption and water efficiency.
10. Innovation.

Credits are awarded according to performance and weighted to produce a single overall score. The performance targets and weightings are derived from consensus obtained from selected members of the building community, including manufacturers, which gives this method the disadvantage of not providing an absolute standard or being complete objective. Although offering a good rage of indicators against which the functional requirements for sustainable building could be checked BREEM Healthcare lacks any robust social component. BREEAM differentiates 11 building typologies and expresses evaluations as a percentage of achieved over total maximum available points: 25 % for Pass classification, 40 % for 'Good', 55 % for 'Very Good', 70 % for 'Excellent', 85 % for 'Outstanding'.

Applying BREEAM Healthcare in practice indicates problems associated with the delineating stages in the project process notably the design to post-construction stages. Specifically, the pre-assessment may either be late in being conducted or not be carried out at all resulting in poor specifications for sustainable building which in turn make for difficult evaluation at the post-construction review. Capper et al. (2004) study also found a common difficulty was that of attaining collective responsibility for achieving credits when project teams could only undertake to achieve an excellent rating for their elements of work with some issues determined prior to the appointment of the design team (Fig. 3.14).

Another issue is that post-construction review can be carried out based only on 'as built' drawings without reference to the completed healthcare facility and

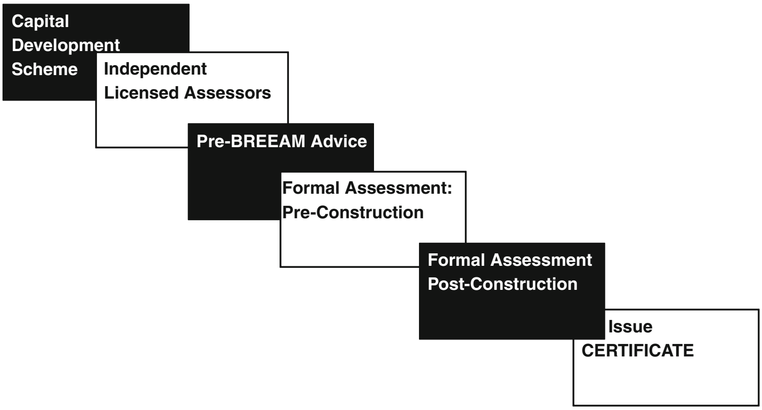

Fig. 3.14 BREEAM process to certification

thereby producing final rating results which do not necessarily relate or represent the building's performance in use. Furthermore, despite the fact that the total credits from applying the BREEAM Healthcare 2008 add up to a maximum of 110 %, achieving 'Excellent' (70 out of 110) rating for new builds or 'Very Good' (55 out of 110) rating for refurbishments although being mandatory yet may be an insufficient condition and incentive for creating green healthcare facilities of quality.

As with many other building assessment methods, BREEAM Healthcare incorporates complementarily or directly national technical guidance, building regulations requirements, standards and tools to provide a more comprehensive evaluation of the building. These include current specific building regulations, BSRIA Standards, Healthcare Technical Memoranda (HTMs), Life Cycle Cost (LCC), Life Cycle Assessment (LCA), DQI, ASPECT and AEDET Evolution. Absent from this list are Health Building Notes (HBNs) considered *a* start point of all healthcare building designs including the fact that the relationship between BREEAM Healthcare and applications such as ADB remains unclear. However, this integrative approach, especially mirrored by the use of LCC- and LCA-based indicators as subsystems within the 'checklist-based' BREEAM Healthcare, signifies a potential trend of recent development—from 'mutual criticism between stakeholders in different technological frames' into a more 'constructive dialogue' (Dammann and Elle 2006, p. 399). Also included are issues from a variety approaches and agendas from Planetree Philosophy to Picker Institute in particular evidence-based design such as 'Hea 2 View Out' from Ulrich 1984 and 'Man 6 Consultation' from ASPECT and AEDET Evolution. Notwithstanding this, since BREEAM Healthcare tool gives overall priority to energy efficiency and CO2 reductions, such evidence-based design matters are considered relatively less important compared to environmental factors in this hierarchical system. Moreover, since most these issues are voluntary, it is possible for project teams to achieve a good BREEAM Healthcare result without ever considering or addressing them. Crucially, studies are required to investigate healthcare facilities highly rated by BREEAM Healthcare in order to find out whether this translates into improved health outcomes and thereby enhance the evidence base for evidence-informed design.

As with other rating methods, BREEAM is keen to provide a robust response to the challenge of developing a system of data collection and analysis that provides a platform for performance feedback based upon a more holistic qualitative whole-life method of assessment. This means including monitoring and verification.

Leadership in Energy and Environmental Design

Developed in 1998 by the US Green Building Council, LEED™ is intended to provide building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. LEED™ is a voluntary environmental assessment system consisting of a suite of rating systems for the design, construction and operation of high-performance green buildings, homes and neighbourhoods. The goal is to evaluate environmental performance over a building's life cycle and to provide a definitive standard for what constitutes a "green building". Rainwater (2008) remarked that "By far the most common (building assessment system) is the US Green Building Council's LEED™ point system". In 2003, LEED Canada was created for Canada Green Building Council (Fig. 3.15).

LEED™ certification is obtained from the Green Building Certification Institute after submitting an application documenting compliance with the requirements of the rating system as well as paying registration and certification fees. The

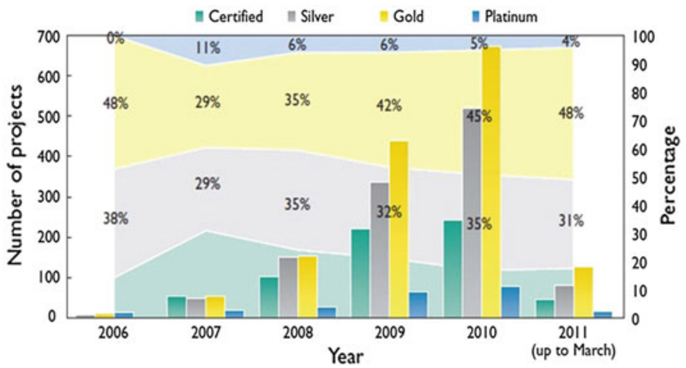

Fig. 3.15 The percentage breakdown of LEED™ certificates 2006–2011 from over 3300 LEED™-assessed buildings including buildings from outside the USA. The study found that LEED™ Platinum is still rare, and the consistently favoured levels of certification are for the silver and gold categories (*Source* Chris Pyke, U.S. Green Building Council).

cost of registering a project for potential LEED™ certification (the first step in the process) is between $450 and $600; the certification fee varies by the size of the project, but averages $2,000. Other costs, such as consulting fees, are not included in those figures (US Green Building Council 2009). LEED™ is available for 10 building typologies according to New Construction, Existing Buildings: Operations and Maintenance, Commercial Interiors, Core and Shell, Schools, Retail, Healthcare, Homes and Neighbourhood Development.

There are 6 evaluation categories to obtain the 69 possible points of the standard: Sustainable Site (14 points), Water Efficiency (5) Energy and Atmosphere (17), Material and Resources (13), Indoor Environment Quality (15) and Innovation and Regional Specificities (5). The sub-sections are a mixture of performance and prescriptive requirements. LEED™ points accumulated are divided into a number of categories: at least 26 points for Certified Buildings, 33 for Silver, 39 for Gold and 52 for Platinum (Fig. 3.15).

LEED™ Healthcare is appropriate for 'designated' uses, i.e., buildings that serve individuals seeking medical treatment, including licensed and federal inpatient, outpatient care and long-term care facilities, and for 'non-designated' uses, i.e., buildings with other kinds of medically related uses such as unlicensed outpatient facilities, medical, dental and veterinary offices and clinics, assisted living facilities and medical education and research centres. In seeking to address the challenge of developing a system of data collection and analysis that provides a platform for performance feedback based upon a more holistic qualitative whole-life method of assessment, LEED™ has also sought to include monitoring and verification. For example, Energy Star Benchmarking and Minimum Programme Requirements all require five-year performance data on all projects. This aims to help to optimise building performance by creating a green building performance database, developing standardisation of reporting and establishing new performance benchmarks.

LEED™ Healthcare represents a joint initiative between the Green Guide for Health Care and US Green Building Council. As the healthcare sector's, first voluntary quantifiable self-certifying metric toolkit that aims to integrate enhanced environmental and health principles and practices into the planning, design, construction, operations and maintenance of their facilities the Green Guide for Health Care is a joint project of the Centre for Maximum Potential Building Systems and Health Care Without Harm. It derives from a programme conducted in 2007 by Green Guide for Health Care encompassing 114 pilot projects in the USA and abroad comprising 30 million square feet of construction. The pilot projects ranged in size, building type, region, demonstrating the Green Guide for Health Care's usability and versatility as an effective tool for different building types and project phases. With agreement from the US Green Building Council, the hierarchical organisational structure is based on that for the LEED™ Rating System for New Construction. Credits are awarded to seven sections: 'Sustainable Sites' (18 %), 'Water efficiency' (9 %), 'Energy and Atmosphere' (39 %), 'Materials and Resources' (16 %), 'Indoor Environmental Quality' (18 %), 'Innovation in Design' (6 %) and 'Regional Priority' (4 %), adding up to a total of 110 %. LEED ™ Healthcare rating or degrees of performance are Certified (40–49 %), Silver (50–59 %), Gold (60–79 %) and Platinum (80+) giving an overall score of up to 110.

However, compared with LEED™ for New Construction, some changes have been made to the prerequisites and credits in the LEED™ Healthcare to reflect the essential differences between healthcare facilities and other types of buildings. The prerequisites refer to 'Environmental site assessment', 'Minimise portable water use for medical equipment', 'PBT source reduction—mercury', 'Hazardous material removal or encapsulation (renovations only)', 'Integrated project planning and design'. The credits refer to the 'Connection to the natural world—places of respite/direct access for patients', 'Water use reduction—measurement and verification/building equipment/cooling towers/food waste systems', 'Community contaminant prevention—airborne releases', 'PBT source reduction—mercury in lamps/lead, cadmium and copper', 'Furniture and medical furnishings', 'Resource use—design for flexibility', 'Acoustic environment', 'Low-emitting materials', and 'Integrated project planning and design'. Evidence-based design principles have been taken into account to inform some of these changes (e.g. 'Connection to the natural world' and 'Acoustic environment').

Both LEED™ Healthcare and its prototype Green Guide for Health Care recognise the collective fundamental mission to protect and enhance individual and community health, thereby acknowledging the intrinsic relationship between the built environment, ecology and health. However, unlike the Green Guide for Health Care, which is a voluntary guide mainly tailored for educational purposes, LEED™ Healthcare, was first issued by US Green Building Council in April 2011 as a guide for the design and construction of both new build premises and major renovations (involving Heating Ventilation Air-Conditioning works, significant building envelope modifications, and interior rehabilitations) and existing healthcare facilities for licensed or federal inpatient care, outpatient care, long-term care facilities and other medically related buildings (e.g. medical offices, assisted living facilities and medical education and research centres). Since 1 January 2012, the requirement is to use LEED™ Healthcare to inform the design if more than 60 % of the building square footage of licensed or federal inpatient, outpatient, and long-term care is dedicated to healthcare use.

Deutsche Gesellschaft für Nachhaltiges Bauen

Developed in 2007 by the German Sustainable Building Council, DGNB focuses on the establishment and further development of a certification system involving a high-performance, transparent, and user-friendly tool for the assessment and certification of sustainable buildings. DGNB's quality concept is based on a holistic view of the building's entire life cycle which aims to take equal account of economics, ecology and sociocultural aspects. It is therefore possible to define sustainability targets beginning in the planning phase.

A voluntary system DGNB assesses both buildings and urban districts which demonstrate an outstanding commitment to sustainability. It covers 6 key quality aspects of sustainable buildings: (1) environmental (ecological), (2) economic, (3) sociocultural and functional aspects, (4) technology, (5) processes and (6) site, whose detailed criteria are, added up to 50. By weighting the first four sections equally in the hierarchical system, DGNB becomes the first and probably the only building environmental assessment method that considers the economic aspect of sustainable building as important as the environmental aspect and thereby distinguishes the DGNB from other building environmental assessment methods such as BREEAM Healthcare and LEED^{TM} Healthcare, which always give priority to environmental concerns (energy saving and CO2 emissions reductions) (Table 3.2).

Covering a wide range of building types: office and administrative buildings, retail buildings, industrial buildings, hotels, residential buildings, mixed-use buildings and educational facilities, DGNB system can be applied to assess the quality of both new (up to 3 years after completion) method for new hospitals allocates different weighting to examination, therapy, and waiting areas as well as administrative areas or commercial areas. In this case, the therapeutic aspect is considered particularly important, and therefore, some evidence-based design principles (e.g. therapeutic environmental issues) have been taken into account to incorporate healing gardens.

The certification process of DGNB has two parts—a pre-certificate stage (for marketing purpose) and a certificate infrastructure stage. The assessment results are determined by the total score for the overall project, which is calculated from the first five quality sections based on their weighting. Site quality is considered separately, and this aspect is included in the marketability criterion. If a performance requirement is successfully met, the building can be awarded a DGNB certificate, which ranges from bronze, silver, to gold. Apart from the total performance index for each award (i.e. Bronze @ 50–64 %, Silver @ 65–79 % and Gold @ 80 % and above), the DGNB sets the entry requirements (i.e. minimum performance index notably Bronze @ 35 %, Silver @50 % and Gold @ 65 %) for all quality sections before an award can be issued. By using an identical assessment system, the implementation of DGNB can keep the consistency of sustainability standards from a single building (micro-scale) to an urban district (macro-scale). DGNB is now applied internationally adapting the system to local climatic, constructional, legal and cultural peculiarities.

Comprehensive Assessment System for Built Environment Efficiency

CASBEE is a tool for assessing and rating the environmental performance of buildings and built environment. CASBBE is managed by the Japan Sustainable Building Consortium, a non-governmental organisation comprising of industry, the

Japanese Government, and academic partners. Policies underlying the development of CASBEE are a simple assessment system for superior buildings that incentivise designers and others while being applicable to a wide range of building types as well as taking into consideration issues and problems peculiar to Japan and Asia.

CASBEE covers the whole architectural design process, starting from the pre-design stage through design and post-design stages for new construction, existing buildings and refurbishment. The system is based on the concept of closed eco-systems represented by two assessment categories: building performance describing criteria such as indoor environment, quality of services and outdoor environment and environmental load describing criteria such as energy, resources and materials, reuse and reusability and off-site environment. CASBEE results are presented as a measure of eco-efficiency on a graph with environmental loads on the one axis and quality on the other. This means that CASBEE sustainable buildings have the lowest environmental loads and the highest quality.

CASBEE Certification System started in 2005 and since December 2011, 24 Japanese local governments have introduced the CASBEE system to provide environment measures that encourage greener buildings.

The idea of Built Environment Efficiency (BEE), which underpins the quality–load (Q-L) method used in CASBEE, was originally developed to define eco-efficiency, i.e., 'value of products and services per unit environmental load'. Quality (Q) or Built Environment Quality 'evaluates improvement in living amenity for building users, within the hypothetical enclosed space (the private property)' while L (Load) or Built Environment Load 'evaluates negative aspects of environmental impact which go beyond the hypothetical enclosed space to the outside (the public property)'. By defining efficiency as input and output properties, a new model is proposed for an expanded eco-efficiency, indicated by the relationship '(beneficial output)/(input + non-beneficial output)'. This formula together with the Built Environment Efficiency has been widely adopted across Asia to inform the development of building assessment methods including the Green Building Assessment System in China (Qin et al. 2007). During the assessment processes, CASBEE uses an indicator LR defining the level of performance in minimising Built Environment Load imposed outside the hypothetical boundary, instead of Q (Built Environment Quality) itself. The assessment scale for Q and LR ranges from 1 to 5, and the BEE is calculated using the formula 'Q/(5—LR)'. The assessment results for buildings can therefore be ranked from class C (poor BEE < 0.5), class B- (BEE: 0.5–1), class B + (BEE: 1–1.5), class A (BEE: 1.5–3), and class S (excellent BEE > 3).

CASBEE does not provide a specific scheme tailored for hospitals or health care unlike BREEAM Healthcare, LEED™ Healthcare or DGNB. Instead, CASBEE for New Construction is used to evaluate the Built Environment Efficiency of healthcare settings as indicated in the case study of the Amami Hospital, Kagoshima, Japan (Horikawa 2008). As a benchmark for the market and by addressing the importance of balancing the output and input during the whole life cycle of built environments, the implementation of CASBEE allows comparison across all types of buildings to enhance market promotion. However, and because hospitals are very different types of buildings, there are doubts as to whether applying CASBEE can properly inform their design, procurement and operation. People might also argue that some design principles for hospitals, such as evidence-based design, are equally relevant to offices, residential buildings, and industrial buildings in improving users' health, well-being, efficiency and productivity.

National Australian Built Environment Rating System

NABERS is a national initiative managed by the New South Wales Office of Environment and Heritage providing a performance-based rating system for existing buildings measuring the existing building's environmental performance during operation. Based on two typical building typologies—domestic and commercial—NABERS gives buildings yearly rating in relation to building performance and the user performance. Designed for use on a voluntary basis NABERS is applicable to all buildings both new and old to give an overall score based on a wide range of parameters. The aim is that all local authorities adopt the rating system in tandem with building codes.

As a very "broad brush" and comprehensive tool NABERS rates a building on the basis of its measured operational impacts in categories such as energy, water, waste and indoor environment, transportation and location. NABERS therefore rates a building on the basis of its measured operational impacts on the environment and provides a simple indication of how well these environmental impacts are managed compared with those by peers and neighbours. By using absolute targets rather than consensus benchmarking NABERS is unique in its aim to provide an accurate, quantitative assessment process based on the use of performative clauses. The use of performance clauses rather than checklists or prescriptive measures helps to ensure that it has the potential to undergo a continual process of evolution and upgrading. However, NABERS requires restructuring to facilitate use as a design tool and as a means of compliance with requirements outlined in "Meeting the Needs" through performance standards.

NABERS uses standards based on the best available science at any time that changes as information improves. As with other targeting tools, it is used to set development guidelines for flagship projects in order to exceed regulatory standards. With NABERS, the State and Local Government is imposing ad hoc energy and environmental performance requirements through local planning regulations and developing their own rating and certification schemes.

Unlike any other building environment assessment methods that often cover the whole life cycle of buildings, NABERS only focuses on the operational phase of building occupancy. Consequently instead of informing the design of new buildings, NABERS mainly assesses the actual operational performance of existing buildings and tenancies in order to inform building users to change their existing lifestyles towards greater environmental awareness. NABERS self-assessments allow building users to evaluate the performance of their buildings themselves though the accredited NABERS rating needs to be done by an NABERS Accredited Assessor. Furthermore, by keeping the rating on an annual basis with the NABERS rating certificate valid for 12 months, NABERS allows building users to keep track of performance, measure the impact of any actions taken, address issues and make improvements, as well as setting targets annually. NABERS uses measured and verified performance information, such as bills, and converts the results into an easy to understand 6 star rating scale of one to six stars: 6 = Market-Leading Performance, 5 = Excellent Performance, 4 = Good Performance, 3 = Average Performance, 2 + Below Average Performance and 1 = Poor Performance. A 6 star rating demonstrates market-leading performance, while a 1 star rating means the building or tenancy has considerable scope for improvement.

A contract for NABERS commercialisation was signed in March 2005. The NABERS team is also currently developing a hospital rating program to measure the environmental performance of public hospitals in New South Wales and to encourage more sustainable hospitals.

TERI Green Building Rating System

Developed in 2004 by The Energy and Resources Institute, TGBRS is a rating system for Indian buildings based on the internationally accepted rating systems—the US-based LEED™ and the UK-based BREAM (Building Research Establishment's Environmental Assessment Method). Through defined qualitative and quantitative assessment criteria, TGBRS rates a building on the degree of greenness and is applied to both new and existing commercial, institutional and residential buildings.

TGBRS is a voluntary, consensus-based standard for developing high-performance, energy-efficient sustainable buildings. Buildings are graded for site planning, transportation around the site, external lighting, water and waste management, use of energy, efficient materials, indoor environment quality and design innovations (Table 3.2).

Green Hospital Building Evaluation Criteria China

Issued by the Chinese Hospital Association in July 2011, The Green Hospital Building Evaluation Criteria (GHBEC) represents the first sustainable architectural healthcare design guidance customised for healthcare facilities to best meet the needs of Green Hospital construction in China. The criteria forms part of concepts within the healthcare sector to build green hospitals first introduced in China during the 2000s and evident in the trend recognised locally by adopting the US Green Guide for Health Care for medical buildings.

Table 3.2 Comparison of BREEAM, LEED™ and DGNB building environmental assessment methods

	BREEAM	LEED™	DGNB
Green Building Organisation	United Kingdom Green Building Council	US Green Building Council	DGNB *e.V* (German Sustainable Building Council)
Country of origin	*United Kingdom*	*USA*	*Germany*
Year started	1990	1998	2007
Certified buildings	>100,000	>8189	>78
Countries using the method	*UK, Ireland*	*USA and over 130 countries worldwide*	*Germany, Bulgaria, China and Austria*
Degrees of performance	>25 % pass >40 % good >55 % very good >70 % excellent >85 % outstanding	Certified (40 %), Silver (50 %) Gold (60 %) Platinum (80 %)	Bronze Silver Gold
Other comments	As "Green Building" label focused on ecological aspects	As classical "Green Building" label focused on ecological aspects (energy)	No classical "Green Label" but with a large range of sustainability criteria

The introduction in 2006 of The Green Building Evaluation Standards (GB/T50378-2006) established a green building evaluation criteria system for China. This was followed by The Ministry of Construction issuing the "Management Methods for Green Building Evaluation and Certification" and the "Technical Code for Evaluating Green Buildings" in order to regulate the green building evaluation activities and the development of green buildings. The "Management Methods for Green Building Evaluation and Certification" outlines the green building evaluation and certification, conditions, application procedures and evaluation principles. Green buildings can be classified into three grades—one, two or three star projects. The Ministry of Construction identifies, evaluates and certifies projects, while the Science and Technology Advancement Centre conducts and manages the evaluation activities for the Ministry of Construction.

The "Technical Code for Evaluating Green Buildings" defined the technical guidelines for green building evaluation according to The Green Building Evaluation Standards (GB/T50378-2006). Based on practical experience and international best practice, the codes for both residential and non-residential buildings were formulated by Chinese green building experts. The codes evaluate 6 technical aspects: (1) land use efficiency and surrounding environment, (2) energy saving and efficiency, (3) water saving and resource utilisation, (4) building materials, (5) internal building environment and (6) operational management to provide a weighted final evaluation.

On 12 June 2010, the seminar on Green Hospital Construction Standards and the Hospital Directors Summit Forum was held in the Guangzhou Panyu Central Hospital. This hospital itself is a national green building demonstration project, a renewable energy application pilot project, and a Guangzhou building energy-saving demonstration project. During this event, the Chinese Hospital Association, its Hospital Architectural System Research Institute, and the Green Hospital Leading Group produced a joint five-year plan for green hospital development in China. The plan has feasibility to demonstrate Green Hospital Construction in 2010, Green Hospital Exhibition in 2012, Promotion and Dissemination in 2014, and Appraisal and Evaluation in 2015.

The hierarchical GHBEC has 5 main sections: (1) 'Planning', (2) 'Architecture', (3) 'Equipment and Systems', (4) 'Environment and Environmental Protection' and (5) 'Operation Management'. Under each section, design issues can be categorised into three sub-groups—(a) 'controlled items' with compulsory requirements for any green hospitals; (b) 'general items' with optional requirements for green hospitals; and (c) 'optimal items' with relatively higher requirements that can be difficult for some green hospitals to satisfy.

The GHBEC is applied at two points in the project process before a certificate is issued: first at the design stage and second at the operational stage of hospital occupancy (after at least one year's occupation and completion the whole project to a certain proportion). The GHBEC certifications are awarded according to a scale (CHA 2011) indicated in Table 3.3.

Unlike BREEAM Healthcare which incorporates pre-assessment during the design stage (leading to an Interim BREEAM Certificate), The GHBEC is more retrospective and has yet to be developed away from its original base as an evaluation system. Furthermore, compared to BREEAM Healthcare and LEED™ Healthcare, the GHBEC does not have a hierarchical weighting system to differentiate the relative importance of hospital design issues leaving scope for innovative interpretation and setting of the same targets to be achieved by integrating different items through different approaches. However, with all items in the GHBEC weighted equally, no integrative options or individual design strategies are prioritised limiting the extent to efficiently informing design or providing clear guidance for future technological research and development. In practice, designers and assessors apply the GHBEC as a checklist acknowledging that some items (interior and exterior therapeutic environments, acoustic environments, natural daylighting

Table 3.3 GHBEC—rating benchmarks

Rating for the GHBEC	General items (35)					Optimal items (33 items)
	Planning (6 items)	Architecture (6 items)	Equipment and systems (10 items)	Environment and environmental protection (7 items)	Operation management (6 items)	
1 Star ★	2	2	3	2	2	–
2 Star ★★	3	3	5	4	3	10
3 Star ★★★	4	4	7	5	4	22

Source The Science and Technology Advancement Centre 2012 and its control, natural ventilation and its control addressed) derive from evidence-based design principles. Also, the GHBEC appear to undervalue energy performance factors such as energy-saving measures, unlike BREEAM Healthcare and LEED™ Healthcare. Specifically, the Optimal Item 6.0.26 under the GHBEC, only 3 % annual energy saving is recommended where LEED™ Healthcare has a minimum requirement of 10 % over the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) International Standard. Improving the existing government baseline standard for hospital's energy performance—the Design Standard for Energy Efficiency of Public Buildings GB50189 and customising this for hospitals would help drive up requirements for energy performance.

Design Quality Indicator

Launched in 1999, DQI is a method of evaluating the design quality and construction of new buildings as well as the refurbishment of existing ones. DQI is managed by UK's Construction Industry Council. The DQI process involves a wide group of people responsible for the design and construction, those who will use the building or are affected by it. The process is used on wide variety of buildings, i.e., police stations, office buildings, college and university buildings, libraries, and many other civic and private building projects.

DQI can be used at all stages of a building's development and plays a fundamental role in improving the design quality of building projects. DQI as a benchmarking tool establishes and measures performance in relation to agreed indicators, thereby enabling projects, products and processes to be compared. Benchmarking is, however, consensus-based and therefore makes no attempt to establish absolute targets. It cannot be relied upon to promote the necessary or even the best possible improvements. Since DQI's launch and availability as online resource for the UK Construction Industry on 1 October 2003, three models of DQI have subsequently been developed: (1) DQI applicable to all building types, (2) DQI for schools and applicable to school buildings and (3) DQI for health buildings released in beta format in June 2012.

Achieving Excellence Design Evaluation Toolkit

Developed in 2004 by The University of Sheffield Healthcare Research Group under a commission from NHS Estates (replaced by the Department of Health Estates and Facilities), AEDET can be used on existing buildings and on the plans for new ones. The publication "Advice to Trusts on the main components of the design brief for healthcare buildings" prepared by The Design Brief Working Group (Richard Burton, Chairman) for the UK NHS Estates sets the scene and context for the development and use of healthcare guidance and tools in the UK.

The AEDET Evolution toolkit evaluates a design by posing 59 series of clear, non-technical statements, encompassing the key areas of ‘Impact’, ‘Build Quality’ and ‘Functionality’ designed to cross refer to the pan-industry (construction) tool DQI (http://www.dqi.org.uk/). By scoring these statements, it is possible to summarise how well a healthcare building complies with best practice. The AEDET Evolution also provides a common language that allows clear identification of needs and for a discussion to be initiated between the client, consultants and other parties to the healthcare project. The discussion can take place at any stage during the design–build–occupy cycle, thus ensuring that continuous response to changing client needs and expectations (Fig. 3.16).

As a hierarchical tool, AEDET Evolution has 3 layers—a scoring layer on which you score; a guidance layer that gives more detailed help; and an evidence layer that points to available research evidence. It has long been a proposal for the AEDET Evolution to create a fourth layer an exemplar layer that points to precedents. AEDET Evolution also has 3 main sections under which there are 10 headings each of which will produce a score. The 10 headings summarise how well a healthcare building complies with best practice. The headings have several statements which build up a score for that heading.

AEDET Evolution is a tool specifically directed towards achieving excellence in design rather than ensuring compliance with legislation, regulation and guidance. High scores in AEDET do not therefore necessarily guarantee compliance. In particular, the whole question of sustainability and energy consumption rates of a design are only dealt with in passing in AEDET. This is because another more appropriate tool BREEAM Healthcare exists for the evaluation of designs for environmental considerations and energy consumption. Although AEDET can be used as a standalone tool, a design can therefore only be demonstrated to be fully successful in achieving excellence when AEDET evolution is used in conjunction with BREEAM Healthcare.

The AEDET toolkit assists Trusts and the NHS in determining and managing their design requirements from initial proposals through to post-project evaluation. It supports key agenda items at NHS Design Reviews. As a benchmarking tool,

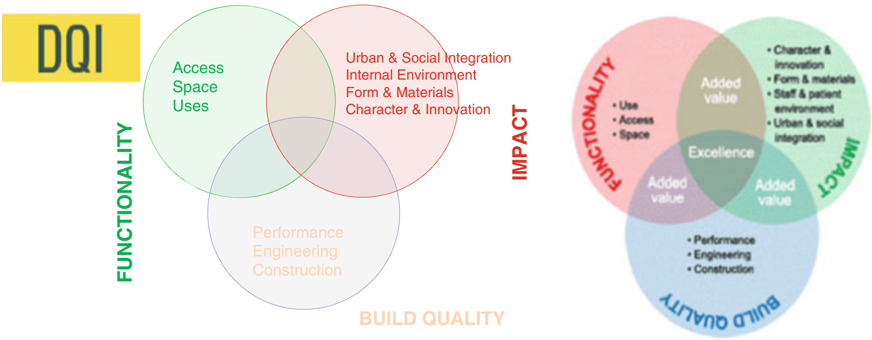

Fig. 3.16 DQI and AEDET evolution underlying framework

AEDET forms part of the business case guidance for ProCure21, PFI, LIFT and conventionally funded schemes.

Since the development of AEDET Evolution as an evidence-based design tool, studies have been conducted which have validated its usefulness. For example, O'Keeffe (2008) found that AEDET toolkit's most important usefulness and influence is in galvanising the project team in delivery of a healthcare project. Nonetheless, there are some practical issues for example, the use of AEDET Evolution as a design quality tool for assessing healthcare schemes in gestation although a mandatory requirement to reach a particular standard in order to be approved is set by individual projects, and these standards have been very variable. Agreed benchmarks for what counts as Excellent, Good and Poor in the overall scoring are required to allow different schemes to benchmark themselves with others in the market.

A Staff and Patient Environment Calibration Tool

ASPECT, a plug-in or Section C (Staff and Patient Environment) of AEDET Evolution is used to provide a more detailed evaluation of the building against the latest known research on the impact of design on patient and staff satisfaction and patient health outcomes. ASPECT therefore ultimately forms part of AEDET Evolution amplifying a number of its exhortations on an evidence base but with specific reference to the staff/patient environment. Studies conducted by Sheffield University Healthcare Research Group using nurses and architects established results produced using ASPECT were consistently more accurate than those obtained using the Heading statements in AEDET Evolution (Figs. 3.17, 3.18).

Also developed in 2004 by The University of Sheffield Healthcare Research Group under a commission jointly funded by NHS Estates, Balfour Beatty Capital Projects and BDP Architects, ASPECT comprises of the 8 headings: (1) Privacy, Company and Dignity, (2) Views, (3) Nature and Outdoors, (4) Comfort and Control, (5) Legibility of Place, (6) Interior Appearance, (7) Facilities and (8) Staff Amenities. As with AEDET Evolution, ASPECT has 3 layers—a scoring layer on which you score; a guidance layer that gives more detailed help and an evidence layer that points to available research evidence. It has also long been a proposal for the ASPECT to develop a fourth layer (an exemplar layer) that points to precedents in the NHS Design Portfolio (images of exemplary healthcare projects). A fifth layer (a compliance layer) has been suggested as a separate document to address issues relating to compliance with statutory requirements, Health and Safety, Fire Code and other NHS guidance and recommendations.

On the scoring layer, each statement may be given a weighting of 0, 1 or 2. However, if a statement is for some reason is not applicable or cannot be used due to lack of information a weighting of 0 can be used to remove it from the calculations. The guidance layer gives a more detailed explanation of the statements and helps on the criteria for achieving good scores. The guidance layer also helps

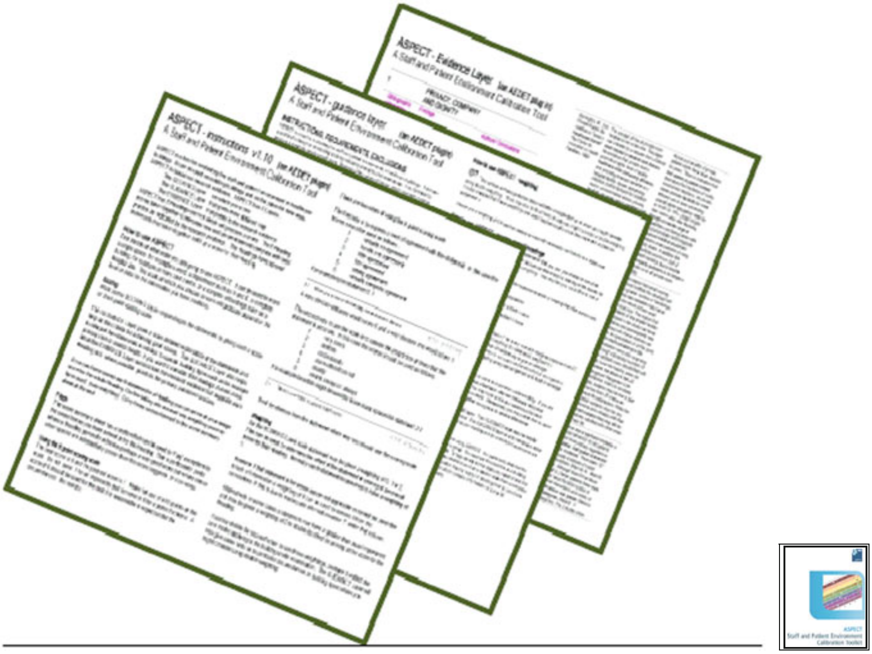

Fig. 3.17 ASPECT is a hierarchical tool consisting of 3 layers: scoring, guidance and evidence Layers

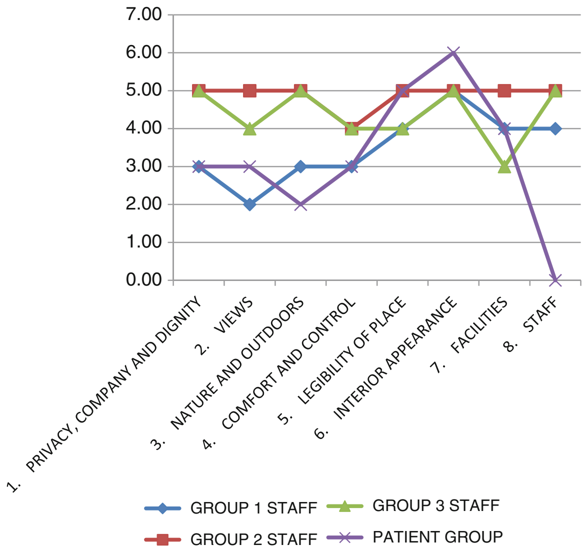

Fig. 3.18 ASPECT summary sheet: a linear graphical output for easy reference. Typical results from a post-occupancy evaluation project show the different profiles or perspectives achieved from 3 groups of staff and 1 patient group—note there was overall general agreement that the interior appearance was above average and therefore scored above 4 out of 6. The patient group gave a maximum score of 6 out of 6 for 6. Interior appearance but did not score 8. Staff

Table 3.4 Typical results from ASPECT focus groups from a post-project evaluation

Aspect categories	Group 1 staff	Group 2 staff	Group 3 staff	Patient group	Average
1. Privacy, company and dignity	3.00	5.00	5.00	3.00	4.00
2. Views	2.00	5.00	4.00	3.00	3.50
3. Nature and outdoors	3.00	5.00	5.00	2.00	3.75
4. Comfort and control	3.00	4.00	4.00	3.00	3.50
5. Legibility of place	4.00	5.00	4.00	5.00	4.50
6. Interior appearance	5.00	5.00	5.00	6.00	5.25
7. Facilities	4.00	5.00	3.00	4.00	4.00
8. Staff	4.00	5.00	5.00	0.00	3.50
Average	3.50	4.88	4.38	3.25	

to interpret the statements in relation to specific building types such as primary care or mental health (Fig. 3.19, Table 3.4).

The evidence layer summarises the research evidence that supports each ASPECT Heading and, where possible, points to the primary published sources. The research evidence has been developed as the Sheffield Staff and Patient Environment Database (Phiri et al. 2000). The database contains around 700 relevant scientific studies, suggesting that factors that the architect/designer has control over can make significant differences to—patient satisfaction, quality of life, treatment times, levels of medication, displayed aggression, sleep patterns, compliance with regimes among many other similar aspects. The database was cross-referenced to a similar literature search conducted in the USA by Prof. Roger Ulrich's team (Ulrich et al. 2004, 2008) which dates back to a review of research literature by Rubin et al. (1998) and their estimates that finding around 125

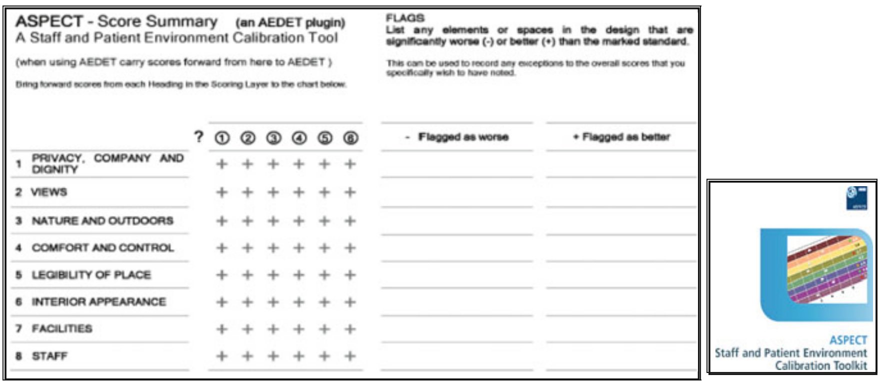

Fig. 3.19 ASPECT summary sheet: layout for a linear graphical output for easy reference. Typical results from a post-occupancy evaluation project show the different profiles or perspectives achieved from 3 groups of staff and 1 patient group—note there was overall general agreement that the interior appearance was above average and therefore scored above 4 out of 6. The patient group gave a maximum score of 6 out of 6 for interior appearance

rigorous studies. Having been produced and published on the Internet as a standalone database using Microsoft Excel software, summarised in CD-ROM format and as a separate Department of Health publication (Phiri 2006), the database is being developed at http://hear.group.shef.ac.uk as a facility planning, design and management resource[1] that makes available summaries of all the original research, together with very basic analysis to those people who wish to check or question its validity. Summaries of existing knowledge complied in a series of reviews of what is currently known can provide a powerful resource for practitioners and policymakers. The reviews themselves also enable researchers to focus their attention on identified gaps in knowledge to be filled.

ADB System and Healthcare Facility Briefing System

ADB is a room-based programming and design system developed in the 1960s to aid briefing, construction, asset management and alteration of healthcare facilities. It is easily identified by standardised room data sheets while the ADB Coding system is generally accepted as *a de facto* industry standard. The UK Department of Health/NHS users of ADB data include:

- Commissioners for the briefing process output briefs or specifications generating schedules of accommodation or producing costing information.
- Commissioners and providers evaluating designs against output briefs or specifications.
- 'Briefers' producing generic room data sheets and standard graphical layouts including designers developing project specific design solutions.

ADB consists of standardised room data sheets and associated graphical room layouts which are used as the basis for deriving project specific designs in turn based on using the functionality of the software to develop, edit and amend the text and graphics to become project specific. It interfaces with AutoCAD, through which it has a feature to produce what are known as 'C Sheets' which consist of plan, elevations, an equipment schedule and a 3D graphical representation of rooms which links back to the textual data sheets. The planner or designer can manipulate the graphics and text and to enable users to undertake repetitive tasks in Excel or CAD assist macros have been developed. ADB has an audit facility which enables the user to record changes within the component schedules. Text and graphical data can be exported in a variety of formats and re-imported if required. It can be edited and a brief can be produced. ADB can interface with BIM processes such as Architectural Desktop and Revit.

[1] Healthcare Environment Architectural Resource (acronym HEAR).

An online survey conducted between 1 March to 31 May 2011 as part of the collaboration of Sheffield and Loughborough Universities under the EBLE Project found that

1. ADB is well regarded as part of tools to aid briefing, planning, design, construction and asset management. Received **27** % responses. Respondents hard a positive view of ADB (**43** %). This is a reflection of the support for the development and application of tools in recent years by the Department of Health.
2. ADB is used by half of the respondents (**51** %). There is scope to increase its use.
3. ADB is used mostly in organisations with under 5 projects and with over 10 projects.
4. ADB is used mostly by organisations working on all three types of buildings large hospitals, small district hospitals and health centres (**19** %).
5. ADB is used mostly projects in the public sector (**45** %) compared to 2 % in the private sector and 21 % in both public and private sectors.
6. ADB is used mostly by organisations working on both New Build and Refurbishment (**48** %).
7. ADB is used mostly in projects with a contract sum of £1–£2 m (**9** %) followed by projects with contract sums of the three values, i.e., under £50000, £500000-£1 m + £1 − £2 m (**8** %).
8. ADB is used mostly at the pre-project and project stages (48 %). It is not surprising that ADB is hardly used at the post-project Stages. There is scope to increase ADB use at this stage.
9. The main benefits and reasons for using ADB at present are because of Department of Health endorsement and compliance (**12** %).
10. The main benefits and reasons for using ADB in the future are to do with Department of Health endorsement (2 %) and both endorsement and compliance (2 %). The respondents who answered this question were small (11).

Initially derived from ADB System, the Australian-based healthcare facility planning system (HFBS) provides an enterprise level data management system that operates at a world scale and has a mission for healthcare planning in its widest sense. HFBS uses the ADB Coding System including reference to ‘Room Data Sheets’ and ‘Room Layout Sheets’ but related to a different comprehensive set of Healthcare Facility Guidelines rather than the UK’s Health Building Notes or Health Technical Memoranda (Fig. 3.20).

The system has modules for service planning, briefing, costing, mapping, asset management and tracking, which operate independently of the concept of drawings and span the entire design–build–occupy cycle. In the HFBS paradigm, information (Briefing) allows translations of client requirements into specifications for design, construction and asset management. HFBSCAD program can be downloaded and is freely available from inside the HFBS, which, however, requires subscription to the HFBS XML service which in turn brings the briefing requirements of the live project into the AutoCAD platform. The annual subscription is $550 per project.

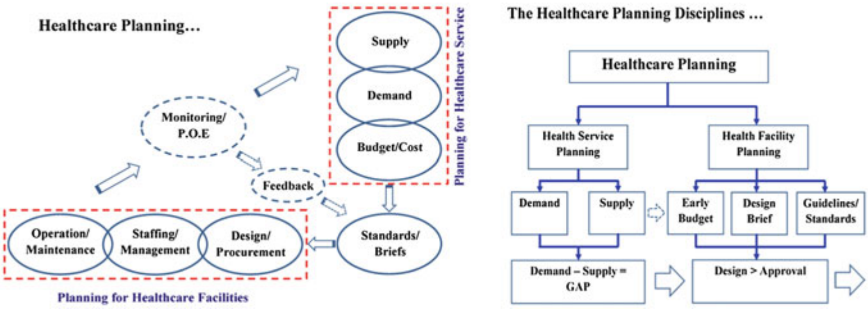

Fig. 3.20 Healthcare facility planning system (HFBS)

Conclusions from a Review of Healthcare Technical Guidance and Tools

A summative rather than a comprehensive review of the healthcare planning information, healthcare facility briefing systems and tools provides an appropriate basis to examine some of emerging issues. The review answers the question of need for technical guidance and tools in health care that compliment building regulations or norms applied to other building types. Healthcare planning information that includes briefing systems is essential because of the complexity of health care to aid the identification and recording of user requirements and formulation of the brief, the design, construction and management of the completed healthcare facility. Hospitals are an important inseparable part of healthcare delivery and have a significant role to play in an approach that integrates evidence-based architectural design and sustainability to create healthy, affordable, efficient environments that demonstrably:

- improve health outcomes, staff efficiency and effectiveness,
- increase patient, family, and staff satisfaction,
- accommodate today's best practices and enhance flexibility to adapt to the future,
- improve patient safety including not endangering occupants through exposure to pollutants, use of toxic materials or designs that provide reservoirs for harmful organisms,
- do not harm the natural environment and consume a disproportionate amount of resources—land, materials for construction,
- are not wasteful of energy, water and materials due to short lifespans, poor design, inefficiency and less than ideal construction, assemblies and manufacturing processes of components,
- minimise dependence on polluting forms of transport,
- do not use materials from threatened species, habitats and environments.

All this means developing policies, strategies, encouraging behaviours and life styles that allow for effective use of existing landscapes and renewable energy, meeting site, community development and transport requirements, use of energy-efficient and eco-friendly equipment, utilisation of recycled and environment-friendly building materials that are both recyclable and non-toxic, providing indoor air quality for optimal human comfort and safety, efficient use of water, effective monitoring, controls and building management systems as well as bio-diversity of the present systems.

The trend for national Green Building Councils developing their own environmental assessment methods or adapting to one of the existing schemes also sees all these methods fighting head-to-head for global tenants worldwide. In all the building assessment methods, uncertainties and substantial gaps still prevail for the assessment of social aspects, a consensus on 'appropriate indicators that are directly applicable for single buildings' has yet to reached (Lutzkendorf and Lorenz 2006, p. 343). Likewise, there is yet to a single, universally accepted methodology for conducting a health impact assessment (Bendel and Owen-Smith 2005).

Guidance and tools have also been specifically developed for the healthcare sector, for example BREEAM Healthcare, LEED™ Healthcare and The Chinese GHBEC. In practice, the implementation of technical guidance and tools raises an important issue of voluntary versus regulatory compliance to satisfy functional standards. For instance in the UK, BREEAM Healthcare is applied on a voluntary compliance basis in England relying on forms of incentives such as taxes, levies and grants or subsidies to promote changes in practice and on raising awareness of issues for healthcare clients, while in Scotland, this is regulatory compliance with penalties for non-compliance. Whatever the case, research is needed to establish which of these delivers either value for money and better outcomes or their usefulness. However, reliance on voluntary green building certification alone may have very limited potential impact such that regulations may also be required to minimise the environmental impacts of buildings.

Reliance on voluntary compliance alone to satisfy functional standards and deliver sustainable buildings may also be inadequate for cost reasons. Key underlying issues are the prohibitively long time span for recovering the costs of investments in sustainable buildings and buildings-in-use and the fact that the investment is usually shouldered by developers and project sponsors (who often do not enjoy the cost savings and benefits) rather than the occupants and owners. This makes incentives a crucial component in order to encourage the developers and project sponsors to invest in green buildings. Overall, using a combination of compulsory and voluntary measures to provide a degree of choice to developers and architects may ultimately be a more effective strategy.

An important issue with regard to the implementation of healthcare guidance and tools concerns the balance between design quality and building performance assessment tools. The approach advocated in this brief is that design quality standards and tools exemplified by DQI, AEDET, ASPECT should not be seen as competitive or divorced from but as complementary to Building Environmental Assessment methods typically exemplified by BREEAM, LEED™, DGNB and

CASBEE. Of relevance, sustainability assessment of construction entails considerations at both whole building and building product level. Quantitative assessments of the benefits of recycling of construction materials at their end of life are recognised in assessment systems and standards. Valid recyclability–measurement approaches typically use two indicators—"Recycled content", which looks at how much recyclable material is used in the production of a new product, and "End-of-life recycling rate", which compares the actual amount of material obtained from recycling with the amount of material theoretically available at the end of the life of a product.

Procurement of buildings through green design principles and use of tools developed to evaluate environmental performance is a robust way of dealing with problems arising from hospitals being largely responsible for a significant proportion of world energy usage, raw material consumption, fresh water withdrawals, carbon dioxide (CO_2) emissions and municipal waste production (Brochner et al. 1999, Retzlaff 2010, Tétreault and Passini 2003, Todd et al. 2001). In the UK, tighter legislation, the introduction of the carbon reduction commitment and targets as well as rising global energy costs, the time has never been more important to optimise business energy use in both new capital projects and existing buildings. There is increasing realisation worldwide that in order to meet commitments and aspirations of creating healthy, affordable efficient and sustainable environment it is vital to address issues of the existing building stock or healthcare estate rather than merely dealing with new construction.

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Chapter 4
Case Studies: Design Practice and Application of Healthcare Technical Guidance and Tools

Case Studies from America (USA) + EU (including UK)

New Aarhus University Hospital, Skejby, Denmark

Aarhus University Hospital is one of the 16 (41.7 billion danske kroner, 5.5 billion Euros) Hospital Projects that are receiving a grant from the Danish government. Another 22 hospital construction projects are to be financed solely by the regions. A consortium (C.F. Møller, Cubo Arkitekter A/S, Ramboll, Søren Jensen and Alectia) won an international competition in 2007 to design and lead the construction of The New University hospital in Aarhus, Denmark. An extension of the existing Aarhus University Hospital, Skejby, the new hospital has been designed to accommodate future requirements with regards to technology, forms of treatment and work routines. In 2005, the regional authority had gathered all hospital functions under the Aarhus University Hospital at Skejby, while in the process closing down 3 older hospitals in the city centre.

The hospital site is modelled after an existing Danish town, Ribe, with low buildings on the outside and increasingly taller buildings at the centre. The layout is organised in an urban hierarchy of neighbourhoods, streets, and squares that provide a basis for a diverse, dynamic and green urban area (Fig. 4.1, Table 4.1).

For clarity, the complex is divided into seven professional communities with their own identities. The hospital 'town' is designed to contain a six-storey building with a central arrival area, treatment departments and beds; three high rise buildings housing the administration department, accommodation for research and a patients' hotel (Fig. 4.2). A reception area and facilities for a conference hall, shops, a bank and a cinema are provided on ground floor. Overall, the aim is for a hospital town that functions in the best possible way, both as a treatment facility for approximately 700,000 patients a year and as a place of work for 9,500 employees, 1,000 scientists and students. The projections are that of the hospital serving 4,200 patients per day (3,800 day patients, 330 admissions, 85 acute admissions. and 160 patients in the emergency department) by 2018.

M. Phiri and B. Chen, *Sustainability and Evidence-Based Design in the Healthcare Estate*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-3-642-39203-0_4, © The Author(s) 2014

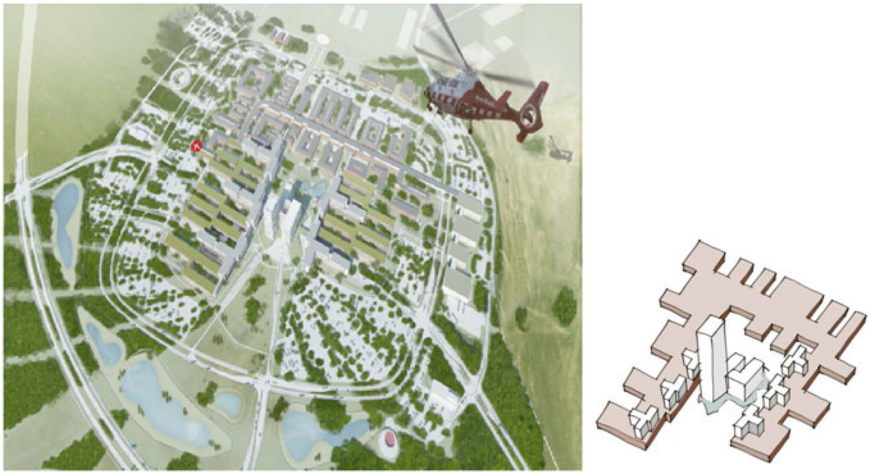


Fig. 4.1 New Aarhus University Hospital, Denmark—Aerial view of master plan + isometric typology (*Source* Møller 2012). The hospital site is modelled after an existing Danish town, Ribe, with low buildings on the outside and increasingly taller buildings at the centre

Table 4.1 New Aarhus University Hospital Denmark—Factsheet

New University Hospital, Aarhus, Denmark—Factsheet
Building description: The hospital site is modelled after an existing Danish town, Ribe, with low buildings on the outside and increasingly taller buildings at the centre. The complex is divided into seven professional communities, each with their own specialist services. The hospital town has been designed to contain a six-storey building with treatment departments and beds, and a central arrival area; three high rise buildings housing the administration department, research facilities and a patient hotel and the ground floor providing a reception area and facilities such as a conference hall, shops, a bank and a cinema
Size: 250,000 m^2, total floor area: approx. 376,000 m^2, total plottage: approx. 970,000 m^2, (Total Number of beds = 812, ICU beds = 86, Daycare beds = 184, Dialysis units = 52, Beds in the Patient Hotel = 80, Operating Theatres = 70 and Ambulatory Treatment Units = 563)
Costs: Costs = 8.67 million DKK (€1.17 billion) (New construction 6.35 + Renovation of Existing Buildings 0.43 + Equipment 0.80 + Utilities Infrastructure 0.27 + Core Centre in the Forum 0.82) Cost per m^2 = 8.67 m/376,000 DKK (€1.17b/376,000)
Completion: 2020
Client: Region Mid-Jutland
Client consultant: NIRAS A/S—The **D**et **N**ye **U**niversitetshospital (DNU) consultant group, which won the commission for the New University Hospital in December 2007
Architects: C. F. Møller Architects in collaboration with Cubo Arkitekter A/S and Avanti Architects Ltd (UK)
Landscape architects: Schønherr Landskab A/S, Tegnestuen Havestuen
Engineering: Rambøll Group A/S, Alectia A/S, Søren Jensen Rådgivende Ingeniørfirma
Other collaborators: Nosyko AS, Lohfert & Lohfert AS, Capgemini Danmark A/S

(continued)

Table 4.1 (continued)

New University Hospital, Aarhus, Denmark—Factsheet
Evidence-based design features: Deriving from the Evidence-Based Healthcare Design approach, The **D**et **N**ye **U**niversitetshospital (DNU) consultant group developed "The Healing Wheel of the Environment" as a basis and generator for planning the entire hospital project. The twelve components of the Healing Wheel of the Environment are the following: **Empowerment & Ergonomics, Daylight, Single-bed Rooms, Acoustics, Artificial light, Access to Landscaped Areas, Communication & Logistics, Textures, Indoor Climate, Art, IT and Design & Décor**. In practice this means a focus on evidence-based design criteria supportive to healing, empowerment, optimal working conditions while securing efficient and professional care and reduction of stress and strain
Sustainability features: These are largely based on learning from the idea of a traditional 'walkable' town which has evolved over a period of time. A key goal is a focus on sustainable solutions in design and execution, low energy consumption and high HSE standards. Another vital goal is an emphasis on flexibility, generality, adaptability and standardisation (e.g. 2,500 standardised rooms based on 45 standard types) as well as allowing for functional changes without changing basic installations and construction, facilitating time and cost efficient rebuilding and reducing production losses Use of innovative products because of their positive effect on the indoor climate. Selection of natural materials to ensure that a large amount of the materials used can be recycled, and that the building components and assemblies are themselves based on recycled materials. Partial or complete visually stunning and durable wood cladding is the preferred solution for walls and surfaces in the public areas, such as the Forum, arcades and squares Green roofs are incorporated in Aarhus University Hospital Project for their benefits of reducing heating (by adding mass and thermal resistance value), cooling (through evaporation) especially in summer and reducing storm water run-off. This saves energy. Green roofs filter pollutants and carbon dioxide out of the air to reduce air borne infections and diseases (asthma), filter pollutants and heavy metals out of the rainwater, and insulate the building from noise (the soil lower frequencies while the plants block higher frequencies) mitigating the problem of increased use of hard surfaces or landscaping

Fig. 4.2 New Aarhus University Hospital, Denmark—Main approach + diagram of the forum (*Source* Møller 2012)

The vision is for a healing environment, which not only puts human needs at the centre, but maximises flexibility of the facilities to respond to the rapid dynamic development of new examination, diagnostic and treatment technologies and is a union of architectural and technical design combined with expertise within medico, IT, environment and working environment. The focus on human needs has also meant the extensive use of evidence-based design, involving employees and patients in the design process.

The New University Hospital in Aarhus aims to represent a physical model of the hospital of the future: a patient-centred hospital founded on concepts of the healing environment, technological innovation and health-promoting surroundings, which point the way to future hospital architecture. Patient-centredness refers to the human being and as such the human scale a measuring rod in which individual patients, and visitors are not only able to find their way around the hospital but also feel comfortable and secure in the new hospital complex. A clear and comprehensible spatial organisation is provided, in a hospital whose goal is an understandable building that guides patients and visitors intuitively to their destinations.

Traditional towns, with their easily recognisable structure, form and functional diversity produced by identity-creating qualities based on the human scale, offer an image of a hospital town and a conceptual starting-point or a mechanism for organising the accommodation and its diverse functions. From a distance, the skyline of the homogenous hospital complex increases in height towards the centre—a stylised picture of the traditional town on a base of red buildings with taller Ward buildings clustering around the hospital's large interior landscape spaces and some very tall tower blocks marking the hospital's central thoroughfare. The New University Hospital, therefore, uses three primary organising elements that promote flexibility and adaptability: (1) a two-storey treatment centre, with outpatient departments and the common clinical department; (2) Ward buildings as decentralised units; and (3) The hospital's 'Forum'—the central arrivals area, where the public functions are located at the foot of three New University Hospital blocks (Figs. 4.3, 4.4).

These three elements are linked, activated and shaped by an intricate network of functions and circulation routes, providing an urban hierarchy of spatial qualities that complements the functional organisation of the professional communities. This basic composition provides a number of advantages. For example, phased extensions of the hospital can overtime take place to respond to changing political and economic conditions. Also the hospital's compact character is thus carefully balanced against decentralised aspects that help to break down its large scale in favour of smaller more intimate local units (Figs. 4.5, 4.6, 4.7).

The hierarchy of neighbourhoods, streets, and squares from the general level of the distinctive public 'Forum' to the local decentralised squares indicates a logical hierarchical progression from 'public spaces—semi-public—private spaces and their intimate atmosphere', a crucial elements for understandable place-making. The urban designations are meant to refer to classic spatial sequences to give patients and visitors an immediately comprehensible physical frame of reference

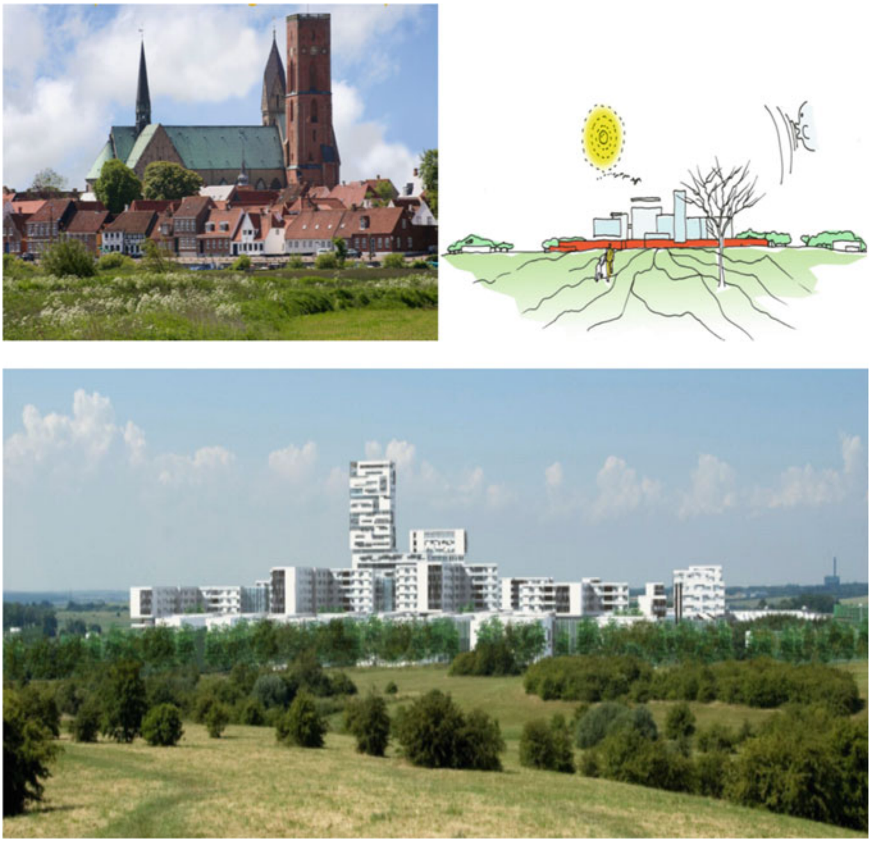


Fig. 4.3 New Aarhus University Hospital, Denmark—Design concept in the image of the Hospital City (*Source* Møller 2012)

for the individual places. The hospital mirrors the continuum of care and all aspects of life—from children playing in the gardens and the play areas of the Forum, to the more emotional moments which demand spaces that offer privacy, dignity, tranquillity and serenity (Fig. 4.8).

The Public Forum is the most important thoroughfare: a distinctive, capacious public space which occupies a central position as the complex's centre. From here, circulation routes branch out towards the professional communities via open arcades. The arcades to the north-east connect to the existing main entrances, which have been incorporated into the complex's new traffic system, while to the south provide a transition zone to galleries that form decentralised nodes in comprehensible neighbourhood sizes that give each professional area its own individual physical character.

The overall style of the New University Hospital in Aarhus favours the decentralised over a more compact building character, partly in order to retain and

Fig. 4.4 New Aarhus University Hospital, Denmark—Main entrance forum: 'the public forum' is the most important thoroughfare: a distinctive, capacious public space that occupies a central position as the complex's centre (*Source* Møller 2012)

Fig. 4.5 New Aarhus University Hospital, Denmark—The hierarchy of neighbourhoods, streets and squares from the general level of the distinctive public 'Forum' to the local decentralised squares indicates a logical hierarchical progression from 'public spaces—semi-public—private spaces and their intimate atmosphere' essential for creating understandable places (*Source* Møller 2012)

enhance the humane character and identity of the existing buildings, and partly to build upon the idea of the town as a model of spatial organisation. Precisely because the patient typically remains within the same area, the intention is to focus on creating spatial identities in the local physical environment that are easily recognisable.

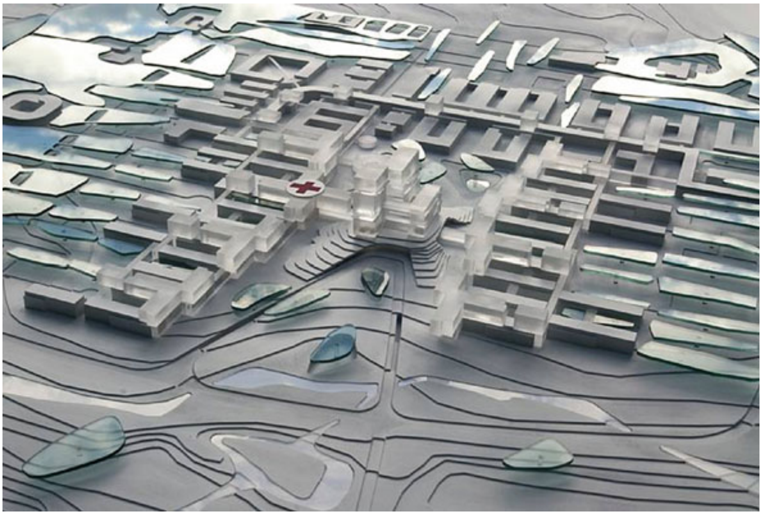


Fig. 4.6 New Aarhus University Hospital, Denmark—model (*Source* Møller 2012)

Fig. 4.7 New Aarhus University Hospital, Denmark—The public forum is the most important thoroughfare: a distinctive, capacious public space that occupies a central position as the complex's centre (*Source* Møller 2012)

Fig. 4.8 New Aarhus University Hospital, Denmark—Day + Night views of the inpatient accommodation blocks (*Source* Møller 2012)

A Healing Environment

On the basis of evidence-based architectural healthcare design (Hamilton 2003), the Det Nye Universitetshospital (DNU) consultant group developed 'The Healing Wheel of the Environment' as a basis for planning the entire hospital project. This Healing Wheel acknowledges work by Florence Nightingale 1885 'The effect in sickness of beautiful objects, of variety of objects, and especially of brilliancy of colours is hardly at all appreciated. People say the effect is only on the mind. It is no such thing. The effect is on the body too. Little as we know about the way in which we are affected by form, by colour and light, we do know this, that they have an actual physical effect. Variety of form and brilliancy of colour in the objects presented to patients is an actual means of recovery (Fig. 4.9)'.

Building on the Florence Nightingale legacy, the hospital project embraces the new focus on evidence-based design. The fact that evidence-based design is a relatively new discipline with a limited scientific foundation has required that the Wheel of the Environment cover only 'evident' areas or components which can be extended over time and at any time. The twelve components of the Healing Wheel of the Environment are as follows: Empowerment and Ergonomics, Daylight, Single-bed Rooms, Acoustics, Artificial light, Access to Landscaped Areas, Communication and Logistics, Textures, Indoor Quality Climate, Art, IT and Design and Décor (Figs. 4.10, 4.11).

1. *Empowerment and Ergonomics*: The patient must as far as possible be able to control their environmental conditions, for example by regulating the lighting, heating, ventilation and music (Guarascio-Howard 2011; Williams and Irurita

Fig. 4.9 New Aarhus University Hospital, Denmark—Circulation: careful planning, design and early or timely considerations to optimise natural light reinforces the positive effect of daylight and prevents discomfort from overheating and glare (*Source* Møller 2012)

2005). Bedside PCs and other devices allow patients to access their own medical notes and journals to enable them to see the times of planned examinations, test results and treatment regimes. Implementing ergonomic design therefore reassures patients, reduces or eliminates fatigue and stress to aid recovery.

2. *Daylight*: Daylight is not just important for our sense of well-being, but also for our health. Daylight ensures that our circadian rhythms are correctly adjusted; it lifts our mood or general atmosphere and has an antidepressant effect. Patients in rooms with windows, particularly windows with views of green landscapes outside, have shorter periods of convalescence and fewer complications and require less pain-relieving medicine (Walch et al. 2005; Figueiro et al. 2002; Beauchemin and Hays 1996; Ulrich 1984). Careful planning, design and early or timely considerations to optimise natural light reinforces the positive effect of daylight and prevents discomfort and other problems that natural light can cause, such as overheating and dazzling glare. Besides improving personal comfort, the conscious use of daylight also helps to save power consumption from artificial light. In so doing, the optimum use of daylight thus has both an environmental and an economic dimension.

Fig. 4.10 New Aarhus University Hospital, Denmark—Single inpatient bedroom (*Source* Møller 2012): research shows that well-designed spaces with maximum natural light will minimise hospital-acquired infections, improve patient safety, enhance privacy, improve communications and confidentiality, and speed recovery. At approximately 24 m^2 in area, the size of the single bedroom complies with requirements for acuity-adaptable rooms. Typically, fully adaptable rooms are designed within the 18.6–27.9 m^2 (280–300 NSF) range with the toilet and shower room ensuite as extra

3. *Single-bed rooms*: Research shows that single-bed rooms offer many benefits, including fewer hospital-acquired infections, reduced medication errors and lower noise levels (Ben-Abraham et al. 2002; Hahn et al. 2002; McManus et al. 1992; MacLeod et al. 2007; Hagerman et al. 2005).

Single-bed rooms facilitate mobilisation of patients, i.e., to get up to socialise, eat or meet other patients or family and friends, shop for essentials and to move around and exercise thus meeting the needs for physical activity and well-being. They offer privacy and confidentiality for conversations with clinical staff avoiding being overhead, a basis for better treatment. The arguments in favour of providing multiple-bed rooms are usually that they are less expensive (to build and operate), but in fact, the shorter periods of admission to and stay in hospital indicate that single-bed rooms are more economic from the point of view of society.

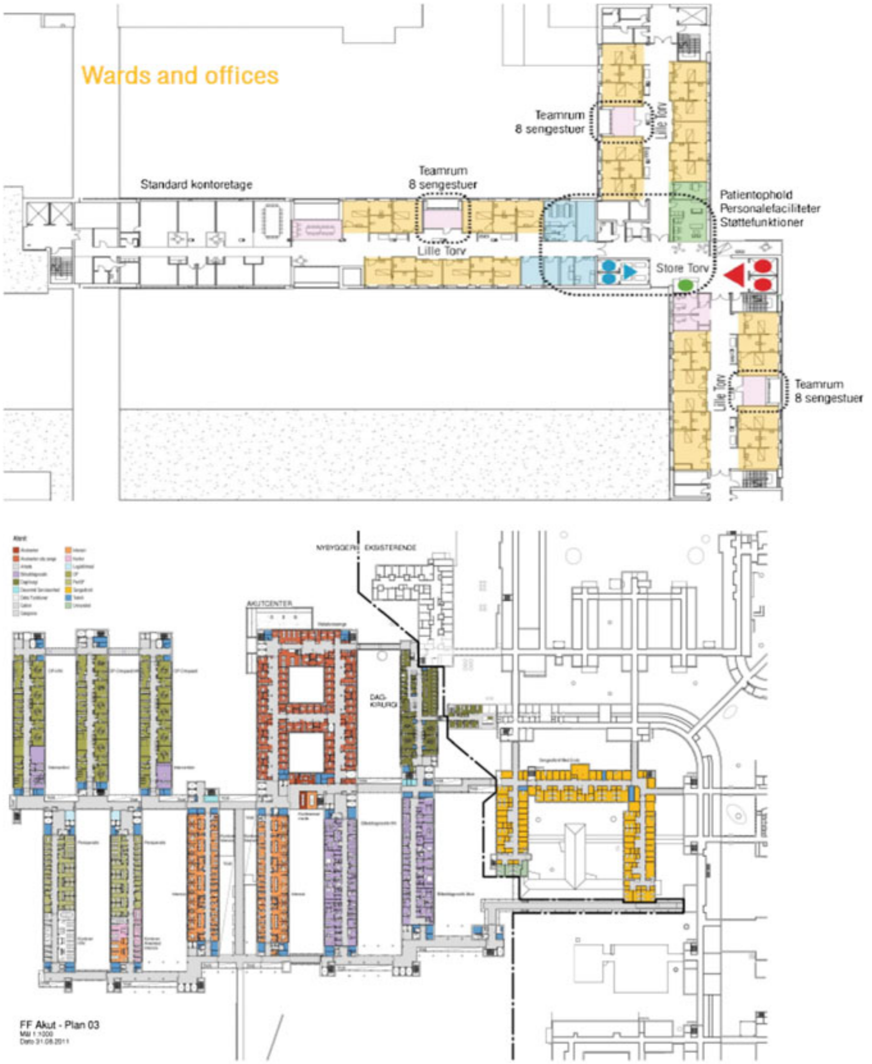


Fig. 4.11 New Aarhus University Hospital, Denmark—Typical floor layouts (*Source* Møller 2012)

4. *Acoustics*: A room's acoustic properties determine how sounds are disseminated. Noise levels in hospitals have been increasing (recorded levels average in the mid-40s and peak at nearly 100 dB—as loud as a lawnmower) (Busch-Vishniac et al. 2005), with many simultaneous and different noise sources, such as people walking, talking or working, beeping sounds from equipment, and noises from transport vehicles—in spaces in which hard surfaces and materials are routinely specified for cleaning and infection control requirements. Lower

noise levels can lower blood pressure, anxiety and pain tolerance, reduce noise-induced stress for both patients and staff allowing patients the peace and quiet they need to sleep and rest, aspects essential for the healing process. Good acoustic qualities contribute significantly towards a quality indoor climate and are best achieved by selecting the suitable construction principles, an appropriate internal layout or configuration and good sound-absorbing materials (MacLeod et al. 2007; Hagerman et al. 2005).

5. *Artificial Lighting*: Artificial lighting fulfils both functional and aesthetic needs. Flexible and variable illumination is not only essential to enhance task performance and reducing medical errors (Buchanan et al. 1991), improve the appearance of an area or have positive psychological effects and one's sense of well-being, but must also have the capability of being controlled to provide lighting for conducting diagnostics and examinations, for example to evaluate changes in skin colouration or discolouration. The choice of fittings (lamps, indoor and outdoor light fixtures) and light sources are selected to comply with functional, atmospheric and aesthetic considerations as well as to reduce energy use (Li et al. 2010). In this case, artificial lighting in the Aarhus University Hospital will be used in combination with daylight taking over the illumination function when daylight alone (via windows and skylights) is insufficient.
6. *Access to Landscapes Areas*: Patients must have access to gardens and landscaped areas. Nature has a positive effect on stress and fatigue, and its promotion of health and healing is well documented. Studies have shown that a view of and access to natural surroundings can have a pain-relieving effect and can alleviate anxiety and depression (Ottosson and Grahn 2005; Grahn and Stigsdotter 2003; Tennessen and Cimprich 1995; Cimprich 1993). Providing healing gardens in the Aarhus University Hospital will allow patients to move around more, something which has a positive effect on their healing by, for example, encouraging the release of endorphins through exercise or physical

Fig. 4.12 New Aarhus University Hospital, Denmark—Green courtyards *(Source* Møller 2012). The squares and courtyards each have their own individual easily recognisable form, décor and character thereby providing visual landmarks and anchors that aid navigation and wayfinding

Fig. 4.13 New University Hospital, Aarhus, Denmark—The Forum: the hospital's flow patterns are designed to be easily navigable, to be clear, comprehensible or understandable and physically convenient for the different user groups including staff and visitors (*Source* Møller 2012)

activity. The gardens offer sanctuary and convenient places to meet and talk with other patients, family and friends (Figs. 4.12, 4.13, 4.14).

7. *Communication and Logistics*: The New University hospital in Aarhus has been conceived so as to have a dialogue with its surroundings and context as defined by the existing hospital, the future new buildings and the landscaped environment. The hospital's flow patterns are designed to be easily navigable, to be clear, comprehensible or understandable and physically convenient for the different user groups including staff and visitors (Passini et al. 2000). This means avoiding certain floor patterns and dark lines or surfaces that can disorient patients and cause anxiety. The hospital is configured around a large landscape garden ('the Park'), which is its most important distinguishing feature or physical landmark. The squares and arcades of the various blocks each have their own individual easily recognisable form and décor, and thereby their own identity that aids way finding and avoid disorientation. The hospital deploys the latest technologies to facilitate communication, teamwork and user satisfaction, for example, building information is supported by 'speaking signs', i.e., hand-held receivers that can read out signs and information boards in Danish, English, German or Spanish (O'Connor et al. 2009).
8. *Textures/surfaces*: Textures and architectural surfaces are important because they influence and affect all of our senses. To realise the vision of a versatile, sensually and aesthetically rich, healthy and comfortable places, it is essential that hospital organisations, occupational healthcare services, researchers, advisers and public authorities all work together using new communication media and integrating devices (O'Connor et al. 2009) in place-making to create healthy environments that promotes well-being. The New University hospital Aarhus project considers many environmental variables and factors including the way architectural surfaces are engineered, fabricated and finished, the choice of innovative products

Fig. 4.14 New Aarhus University Hospital, Denmark—The hospital's flow patterns are designed to be easily navigable, to be clear, comprehensible or understandable and physically convenient for the different user groups including staff and visitors (*Source* Møller 2012)

because of their positive effect on the indoor climate, the preferred selection of natural materials to ensure that a large amount of the materials used can be recycled and that the building components and assemblies are themselves based on recycled materials. Partial or complete visually stunning and durable wood cladding is the preferred solution for walls and surfaces in the public areas, such as the Forum, arcades and squares.

9. *Indoor Climate*: The quality of the indoor climate of a building influences occupants' health, well-being, quality of life and productivity. In a hospital, the patients are particularly vulnerable, while high productivity is expected of the staff. Accordingly, the indoor climate especially the room temperature, air quality and relative humidity affects its' occupants and artefacts. The basic principle behind the maintenance of an optimum indoor quality climate is that the building and its constituent physical qualities should as far as possible do no harm such as acute respiratory infection from ambient air pollution. Numerous studies have found associations between indoor air pollution and acute lower respiratory infection (e.g. Smith et al. 2000; Ezzati and Kammen 2001), chronic obstructive pulmonary disease (Bruce et al. 2000; World Health Organisation 2002) and negative health outcomes—lung function reductions, immune system impairment and lung cancer (Zhang and Smith 2007).

In the New University Hospital, Aarhus providing an optimum indoor climate is done primarily through the use of heavy, well-insulated constructions and a combination of appropriate window and façade design, use of quality glass and sun

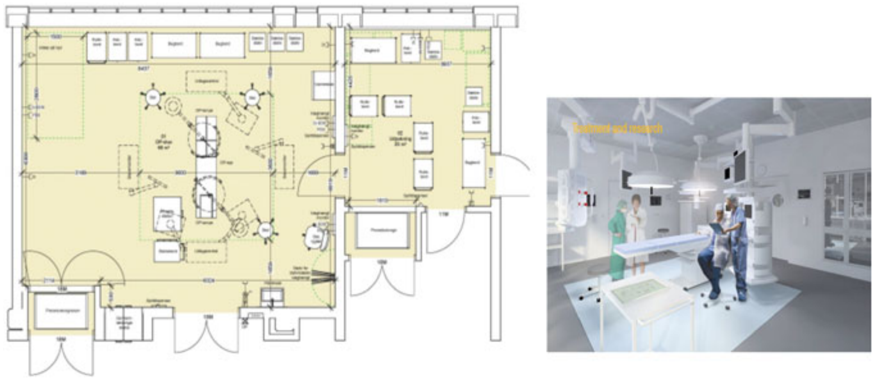


Fig. 4.15 New Aarhus University Hospital, Denmark—Operating Theatres: the basic principle behind the maintenance of an optimum indoor quality climate is that the building and its physical qualities should as far as possible do no harm (*Source* Møller 2012)

screening or shading to overcome any over-heating, insufficient cooling, discomfort and glare. These are supplemented with technical installations that ensure suitable heating, cooling, natural ventilation and/or air conditioning. This minimises dependence on the technical installations, which, besides conferring benefits in terms of energy use, also ensures an optimum indoor thermal climate. In atmospheric terms, the ideal indoor climate is achieved by utilising materials that release no gases, or only release gases in tiny quantities, and via the use of filtered and conditioned air from outside (Figs. 4.15, 4.16, 4.17).

10. *Art*: The Wheel of the Environment identifies the 'rational and evident' as key underlying elements inseparably interwoven because they are define by each other. To meet art is to encounter something else. The appropriate relationship between the visual arts and architecture, and their modes of integration, is a perennial question. Art in the public arena offers distractions, free and enriching experiences (Belver and Ullan 2011; Cusack et al. 2010; Staricoff et al. 2003). Introducing art in previously sterile spaces also can enhance aesthetics. The construction of the New University Hospital Aarhus is regarded as an exceptional opportunity to create original public works of art in special places to aid wayfinding and provide stimulating experiences. By integrating works of art as early a stage as possible in the design process, allows evolution of the art works, design integration as well as provides patients, staff and visitors an opportunity to participate in their development.
11. *IT (Information Technology)*: The hospital of the future is a digital hospital. Installation of wireless IT infrastructure in the Aarhus University Hospital is the logical starting-point to enable both staff and patients to send and receive easily and conveniently information in digital form. Pervasive computing makes health care independent of time and place and serves to improve communication and co-ordination between the various levels within the healthcare sector all of which impact on the way health and social care are delivered.

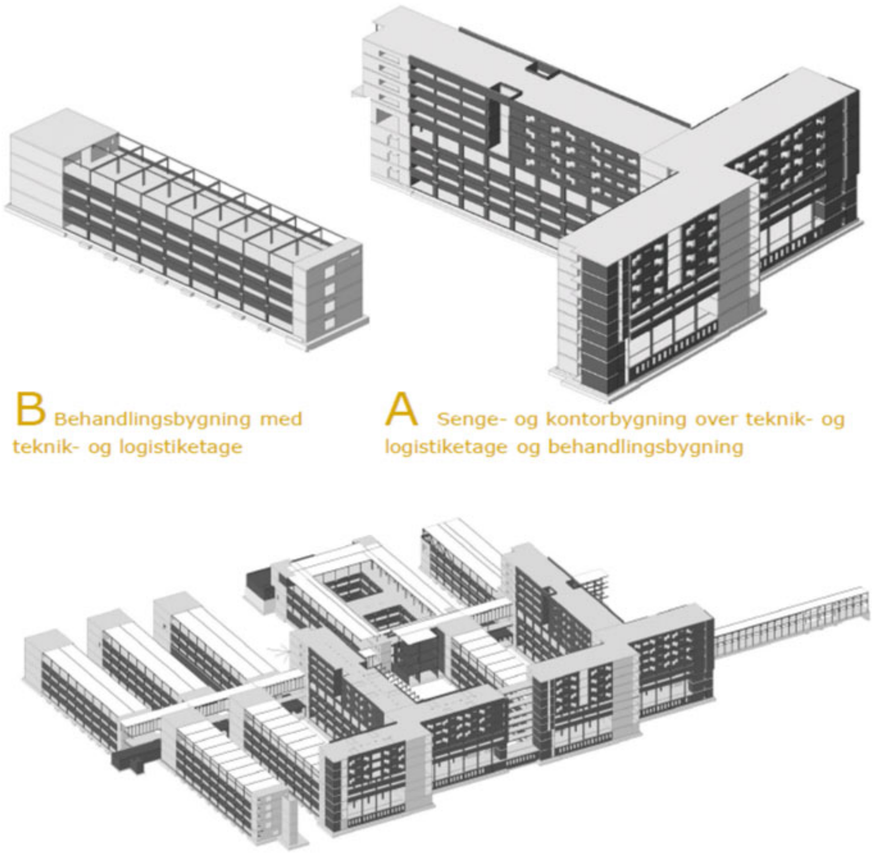


Fig. 4.16 New Aarhus University Hospital, Denmark—two standardised basic type buildings with small variations form 80 % of the total new construction@ approximately 170,000 m^2. The two standardised basic types are combined, mirrored and connected with arcades and galleries in varying patterns and supplemented with unique buildings for specialised functions (*Source* Møller 2012)

Design/décor: In this context, design should primarily be understood as a combination of the traditional view of design and the modern perspective on design as a rational process of problem-solving. At the New University Hospital, Aarhus design décor is meant to contribute to improved solutions for staff, patients and relatives through the conscious use of well-designed, well-functioning products, furniture or fixtures that bring benefits beyond the immediate target group. It is envisaged that equipment design combines advanced technology and attractive appearance with user-friendliness and good ergonomics to contribute to an improved working environment for the staff which reduces operational errors and work-related injuries. A beautiful and friendly design without an overly mechanical appearance will also help to instil confidence and reassure nervous patients.

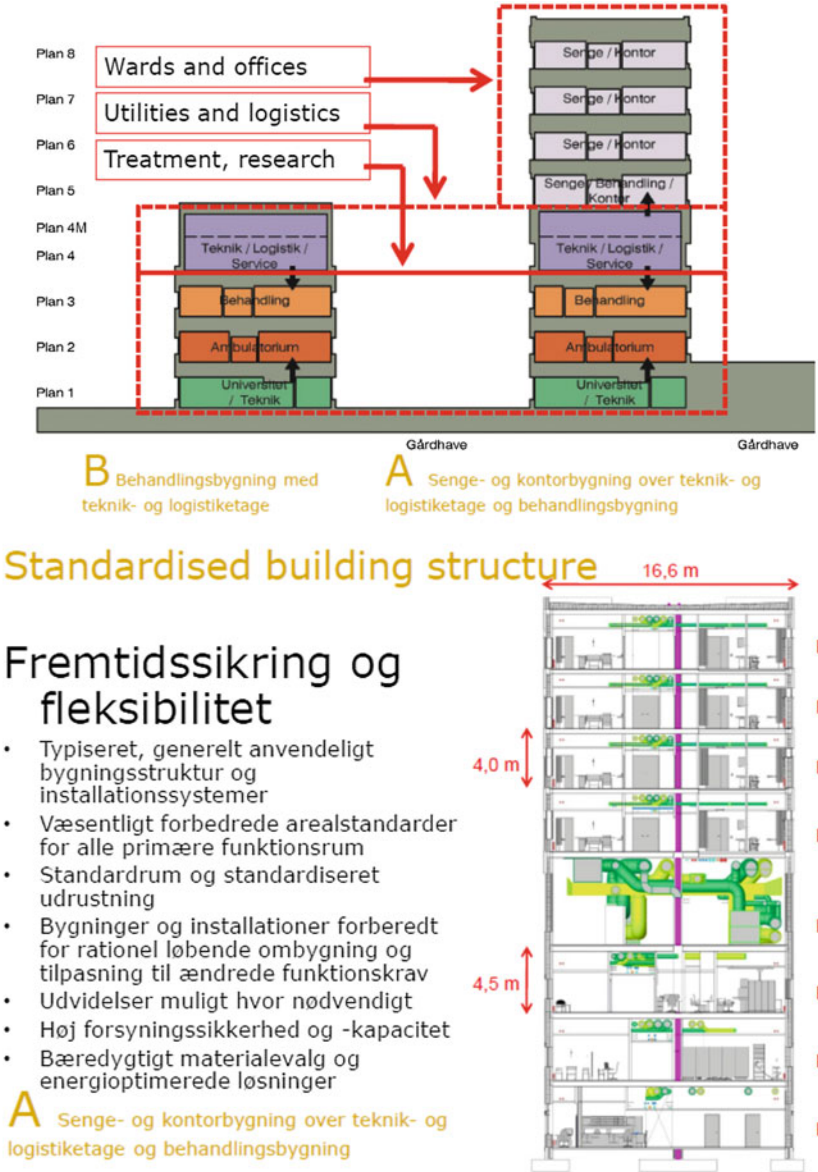


Fig. 4.17 New Aarhus University Hospital, Denmark—A standardised building structure (*Source* Møller 2012)

In the same way, a well-designed patient room with a good decor and choice of materials will satisfy both the staff’s need for an efficient environment with the patient’s need for a friendly and confidence-inspiring space, in which elements from the domestic sphere help to call forth desirable associations and atmospheres, and in the final analysis contribute to more rapid healing and a shorter stay in hospital.

The interior project aims to encompass furniture, fittings and fixtures which support and complement the overall vision of a modern, IT-based efficient, technical hospital which still focuses on the human elements and the individual

12. *Design for Sustainability is indicated as the 13*th *integrating component of the Wheel*: In the Aarhus University Hospital Project sustainability is implemented through learning from the idea of a traditional 'walkable' town that has evolved over a period of time. A key goal is a focus on sustainable solutions in design and execution, low-energy consumption and high HSE standards. Another vital goal is an emphasis on flexibility, generality, adaptability and standardisation (e.g., 2,500 standardised rooms based on 45

Fig. 4.18 New Aarhus University Hospital, Denmark—Typical elevations and green roofs (*Source* Møller 2012). Green roofs are used for their benefits of reducing heating, cooling especially in summer, reducing the electromagnetic radiation that enters a building as well as reducing storm water run-off. Green roofs also filter pollutants and carbon dioxide out of the air to reduce airborne infections and diseases (e.g. asthma), filter pollutants and heavy metals out of the rainwater and insulate the building from noise thereby mitigating the problem of increased use of paved surfaces or hard landscaping

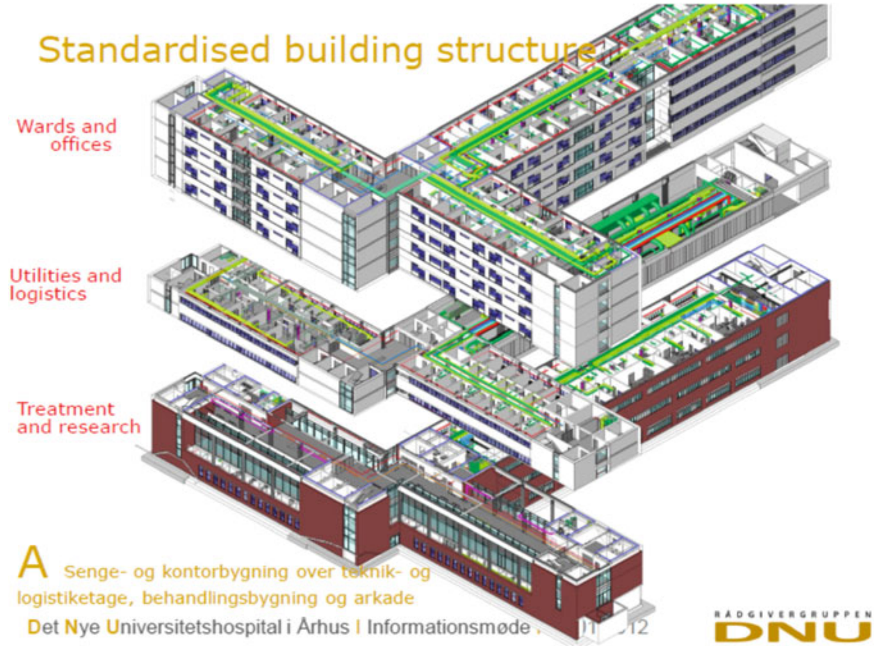


Fig. 4.19 New Aarhus University Hospital, Denmark—Building services and engineering strategy (*Source* Møller 2012)

standard types) as well as allowing for functional changes without changing basic installations and construction, facilitating time and cost-efficient rebuilding and reducing production losses (Tables 4.2, 4.3).

The Aarhus University Hospital Project is still considering what BREEAM rating to register for. It is unlikely that the project will settle for less than BREEAM 'Very Good' classification (>55 %) but more likely to be either BREEAM 'Excellent' (70 %) or 'Outstanding' (85 %) Rating with the latter being a more ambitious commitment for such a large project. This means the project needs to earn the necessary mandatory credits (Tables 4.2, 4.3).

Use of innovative products is made in the Aarhus University Hospital Project because of their positive effect on the indoor climate. Selection of natural materials aims to ensure that a large amount of the materials used can be recycled and that the building components and assemblies are themselves based on recycled materials. Partial or complete visually stunning and durable wood cladding is the preferred solution for walls and surfaces in the public areas, such as the Forum, arcades and squares.

Green roofs are incorporated in Aarhus University Hospital Project for their benefits of reducing heating (by adding mass and thermal resistance value), cooling (through evaporation) especially in summer, reducing the electromagnetic radiation that enters a building as well as reducing storm water run-off (Villarreal

Table 4.2 Minimum levels set for all the 5 BREEAM classified ratings from a 'pass' to 'outstanding' show the onus increasing as the rating rises

<25 %	Unclassified	
>25 %	Pass	To gain a Pass (30 %) Rating Compulsory credits: – Management: Man 1—Commissioning – Health & Well-being: Hea 4—High-Frequency Lighting – Health & Well-being: Hea 12—Microbial Contamination
>40 %	Good	To gain a Good (45 %) Add compulsory credits: – Water: Wat 1—water consumption – Water: Wat 2—water meter In NHS, healthcare facilities achieving a 'Good' rating is mandatory for existing buildings at Outline of Business Case approval stage of a project
>55 %	Very Good	To gain a very good (55 %) rating add compulsory credits – Energy: Ene 2—Sub-metering of substantial energy uses – Land Use + Ecology: LE 4—mitigating ecological impact
>70 %	Excellent	To gain a excellent (70 %) rating add compulsory credits – Management: Man 2—considerate constructors – Management: Man 4—building user guide – Energy: Ene 5—Low or Zero Carbon Technologies – Waste: Wst 3—Storage of Recyclable Waste – Plus in Energy: Ene 1 Reduction of CO_2 Emissions (i.e. an EPC (energy performance certificate) of 40 of less for new build office) a minimum of 6 points must be awarded In NHS healthcare facilities achieving an 'excellent' rating is mandatory for new build at Outline of Business Case approval stage of a project
>85 %	Outstanding	To gain an Outstanding (>85 %) rating in addition to all of the above (plus scoring 85 % or more) add compulsory credits: – Management: Man 2—commissioning needs 2 points – Management: Man 2—considerate constructors – Water: Wat 1—water consumption (Total available in Wat is 3) – Energy: Ene 1—reduction of CO_2 emissions—a minimum of 10 points must be awarded (i.e. an EPC of 25 of less for a new build office) BREEAM—In-use-certification within the first 3 years of operation is mandatory. This involves (a) Collecting user/occupier satisfaction, energy + water consumption data, (b) Using the data to maintain expected performance, (c) Setting reduction targets, monitoring water + energy consumption, and (d) Providing annual consumption & satisfaction data to the design team/developer and BRE. Also the building has to be published as a case study (written by BRE Global)

Note In addition, the building has to have a post-construction review (before then this was not mandatory unless the client required them). It is also not possible to value engineer out the BREEAM features between the design and completion stages without getting penalised (or put another way being caught)

et al. 2004). This saves energy. Green roofs also filter pollutants and carbon dioxide out of the air to reduce air borne infections and diseases (e.g. asthma), filter pollutants and heavy metals out of the rainwater and insulate the building from noise (the soil lower frequencies while the plants block higher frequencies), thereby mitigating the problem of increased use of paved surfaces or hard

Table 4.3 New Aarhus University Hospital—BREEAM 'Outstanding' mandatory credits

	Credits	Description
Management—weighting 12.5 % (Encouraging the sustainable commissioning of the building, environmental management systems, staff education and training and purchasing)	Man 1 [2 credits]	*Commissioning*: Aim to recognise and encourage an appropriate level of building services commissioning that is carried out in a co-ordinated and comprehensive manner, thus ensuring optimum performance under actual occupancy conditions 1 Credit: Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice 2 Credit: Where, in addition to the above, evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post-construction (or post-fit-out)
	Man 2 [2 credits]	*Considerate constructors*: Aim to recognise and encourage construction sites which are managed in an environmentally and socially considerate and accountable manner 1 Credit: Where evidence provided demonstrates that there is a commitment to comply with best practice site management principles 2 Credit: Where evidence provided demonstrates that there is a commitment to go beyond best practice site management principles
	Man 4 [1 credit]	*Building user guide*: Aim to recognise and encourage the provision of guidance for the non-technical building user so they can understand and operate the building efficiently 1 Credit: Where evidence provided demonstrates the provision of a simple guide that covers information relevant to the tenant/occupants and non-technical building manager on the operation and environmental performance of the building
Health & Well-being—15.0 % (Linking and consulting the community, sharing facilities, staff & patient empowerment)	Hea 4 [1 credit]	*High-frequency lighting*: Aim to reduce the risk of health problems related to the flicker of fluorescent lighting 1 Credit: Where evidence provided demonstrates that high-frequency ballasts are installed on all fluorescent and compact fluorescent lamps
	Hea 12 [1 credit]	*Microbial contamination*: Aim to ensure the building services are designed to reduce the risk of *legionellosis* in operation 1 Credit: Where evidence provided demonstrates that the risk of waterborne and airborne *Legionella* contamination has been minimised

(continued)

Table 4.3 (continued)

	Credits	Description
Energy—weighting 19.0 % (Reducing carbon emissions, providing heating and lighting controls, energy monitoring and usage reduction facilities, use of daylight and alternative electricity tariffs)	Ene 1 [10 credits]	*Reduction of* $CO_{2\ emissions}$: Aim to recognise and encourage buildings that are designed to minimise the CO_2 emissions associated with their operational energy consumption 15 Credits: Where evidence provided demonstrates an improvement in the energy efficiency of the building's fabric and services and therefore achieves lower building operational related CO_2 emissions
	Ene 2 [1 credit]	*Sub-metering of substantial energy uses*: Aim to recognise and encourage the installation of energy sub-metering that facilitates the monitoring of in-use energy consumption 1 Credit: Where evidence provided demonstrates the provision of direct sub-metering of energy uses within the building 2 Credit: Where, in addition to the above, evidence provided demonstrates that sub meters are connected to a BMS or other type of automated control device (Schedule of Evidence + Validation Statement: Over 40 sub-meters installed to facilitate data collection via half-hourly meter readings)
	Ene 5 [1 credit]	*Low or zero carbon technologies*: Aim to reduce carbon emissions and atmospheric pollution by encouraging local energy generation from renewable sources to supply a significant proportion of the energy demand 1 Credit: Where evidence provided demonstrates that a feasibility study considering local (*on-site* and/or *near site*) low or zero carbon (LZC) technologies has been carried out and the results implemented 2 Credit: Where evidence provided demonstrates that the first credit has been achieved and there is a 10 % reduction in the building's CO_2 emissions as a result of the installation of a feasible local LZC technology 3 Credit: Where evidence provided demonstrates that the first credit has been achieved and there is a 15 % reduction in the building's CO_2 emissions as a result of the installation of a feasible local LZC technology Alternatively 1 credit: Where evidence provided demonstrates that a contract with an energy supplier is in place to provide sufficient electricity used within the assessed building/development to meet the above criteria from a 100 % renewable energy source. (Note: a standard Green Tariff will not comply)

(continued)

Table 4.3 (continued)

	Credits	Description
Transport—8.0 % (Reducing carbon emissions via provision of car parking, cyclist facilities, proximity to public transport facilities, distance –to-local amenities, green transport plan and compliance with controls assurance)		
Water—6.0 % (Minimising water consumption through leak detection, water use monitoring, low flush toilets and grey water recycling)	Wat 1 [2 credits]	*Water consumption*: Aim to minimise the consumption of potable water in sanitary applications by encouraging the use of low water use fittings
		3 Credit: Where evidence provided demonstrates that the specification includes taps, urinals, WCs and showers that consume less portable water in use than standard specifications for the same type of fittings
	Wat 2 [1 credit]	*Water meter*: Aim to ensure water consumption can be monitored and managed and therefore encourage reductions in water consumption
		1 Credit: Where evidence provided demonstrates that a water meter with a pulsed output will be installed on the mains supply to each building/unit
Materials—12.5 % (Using materials from sustainable sources, prohibition of hazardous substances) BRE's Green Book Live + Green Guide to Specification provide useful information which make it more likely to achieve these credits (and the environmental benefit)		
Waste—7.5 % (Reducing waste, recycling and waste stream analysis)	Wst 3 [1 credit]	*Recyclable waste storage*: Aim To recognise the provision of dedicated storage facilities for a building's operational-related recyclable waste streams, so that such waste is diverted from landfill or incineration
		1 Credit: Where a central, dedicated space is provided for the storage of the building's recyclable waste streams
Land use + ecology—10.0 % (Protecting ecological features and introducing natural habitats, re-use of sites and ecological enhancement)		
Pollution—10.0 % (Monitoring and addressing pollution, NO_x emissions, ozone depleting substances, noise pollution and incineration practices)		
Innovation—9.0 % (Providing additional recognition for a procurement strategy, design feature, management process or technological development that innovates sustainability, above and beyond the level that is currently recognised and rewarded within standard BREEAM issues)		

landscaping. The green roofs create a natural habitat which is of importance for the biodiversity of animal and plant species. Rather than views of concrete and asphalt the green space provided by the green roofs enhances views and experience of nature which help create a relaxing environment that reduces stress from the city. Winner of the Scandinavian Green Roof Award 2009 Handelsfagskolen in Skåde Århus, Denmark sets an example for the Aarhus University Hospital Project (Figs. 4.18, 4.19).

Fig. 4.20 New Aarhus University Hospital, Denmark—Application of the IT tools (*Source* Møller 2012)

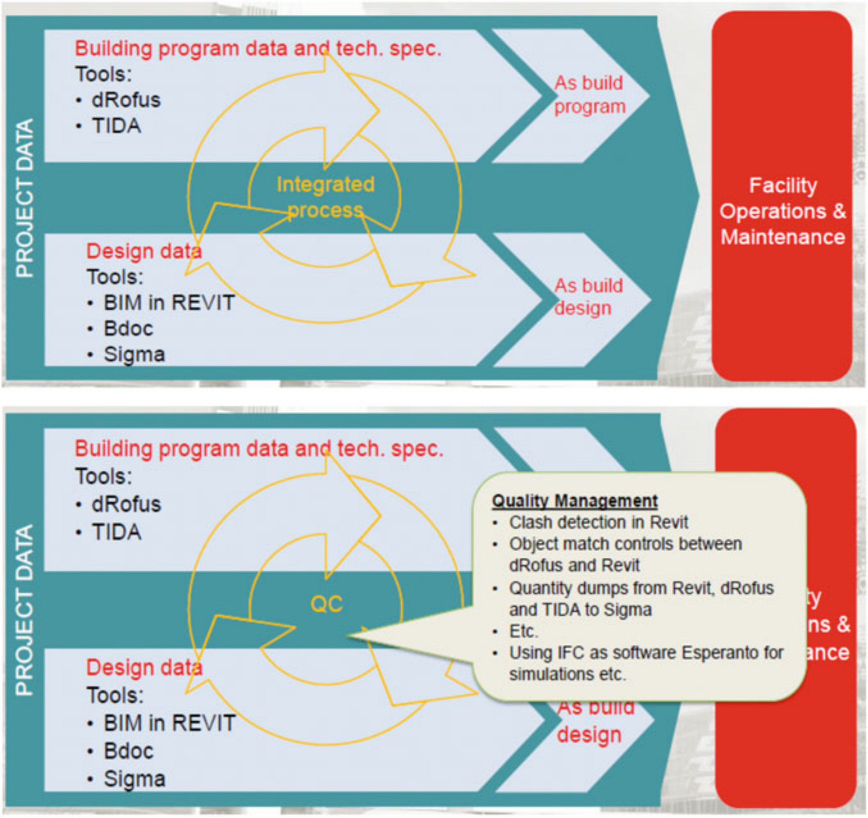


Fig. 4.21 New Aarhus University Hospital, Denmark—Application of the IT tools 2: continual development of project data in use throughout all the stages from building programme, design, tender, construction to As-build and facility O&M. Continual digital work process based on concurrent IT tools and goal of higher quality and reduction of errors and deficiencies (*Source* Møller 2012)

Lessons from the Design of New University Hospital, Aarhus, Denmark

Implementation of the approach that integrates Sustainability and Evidence-Based Design is apparent in that The New University Hospital Aarhus is modelled after an existing Danish town, Ribe and therefore seeks to draw from and repeat successes of the past. This involves recognising the importance of a spatial organisational structure rooted in an urban hierarchy of neighbourhoods, streets and squares that provide a basis for the development of a diverse, dynamic and green urban area. The traditional town is, therefore, a conceptual starting point or a mechanism for organising the accommodation and its diverse functions.

The hospital is not merely a construction project and catalyst for the growth of a diverse and dynamic ‘green’ urban area but also a cultural project, involving the arts and sciences. The intention is that the hospital functions both as a university hospital, a regional centre and a treatment facility for citizens of the region. The Aarhus University Hospital project had clear defined objectives to:

- Increase collaboration to heighten treatment quality and increase clinical efficiency.
- Integrate patient care, research and teaching.
- Provide optimal working conditions and high-quality environment attracting highly qualified personnel.
- Increase facility management efficiency and reduce operational costs.
- Reduce internal transport time and volume.

These objectives were translated into three sets of design project goals.

Design Project Goals I

1. Addressing the size and long-term development of the project with a design strategy focused on the project as a hospital city, a lively and varied urban structure in constant change over time.
2. Strong integration between the hospital city and surrounding landscape, securing excellent views, encouraging use of outdoor spaces for recreational purposes and supporting a healing environment.
3. Functional, technical and logistic integration with the existing hospital based on fully automated transport systems and systematised digital working procedures and processes (Figs. 4.20, 4.21).

Design Project Goals II

1. Focus on evidence-based design criteria supportive to healing, empowerment, optimal working conditions securing efficient and professional care and reduction of stress and strain.
2. Focus on sustainable solutions in design and execution, low-energy consumption and high HSE standards.

Design Project Goals III

1. The design emphasis on flexibility, generality, adaptability and standardisation, allowing for functional changes without changing basic installations and construction, facilitating time and cost-efficient rebuilding and reducing production losses.
2. 2,500 standardised rooms based on 45 standard types.
3. Focus on sustainable solutions in design and execution, low-energy consumption and high HSE standards.

Hospital Planning Information and Guidance has also been established as a context and as a mechanism to facilitate the development or implementation of these design project goals (Table 4.4).

With the development of 'The Healing Wheel of the Environment' as a foundation for planning the entire hospital project, the New University Hospital Aarhus acknowledges the importance of evidence-based design. This validates the importance of the key underlying factors for the evidence-based strategies and interventions in order to provide a healthcare environment that fosters healing, efficiency and effectiveness:

1. Privacy Dignity and Company—allow people to control how and when they share space.

Table 4.4 Hospital planning information and guidance

Adjustment of the dimensioning of the individual projects	
Area:	• Gross/netto factor = 2.0 for Somatik, 1.8 for Psychiatry • Norm for floor area inpatient single rooms (33–35 m^2)
Capacity:	• Projection of Need = Reduction in beds—20 % and increase in number of outpatients visits with 50 % in the period from 2007–2020
General adaption of the area by 20 %:	
	• Enhanced requirements for capacity utilisation (e.g. time for operating the hospital 245 days/7 h). • Building flexibly rather than building large
The economy of the project is to be adapted to Permanent Standards:	
	• New construction of university hospitals on green field 29.000 d.kr./m^2 (incl. 25 % for information technology, scanners, and equipment) • Other new construction and extension 27.000 d.kr./m^2 (incl. 20 % for information technology, scanners, and equipment) • Psychiatric building projects 22.000 d.kr./m^2 • Conversion projects—reduced by 20 %
Locked total frames:	
	• The total frame for the building projects is locked • The regions are not allowed to put any further money into the building projects • Have to build exactly the number of square metres that is indicated in the commitment from the government • Allowed to build more than m^2—but not fewer • Square metre price is fixed • 20–25 % to IT, apparatus and equipment is tied to a specific definition • 70 % of this frame has to be used on Patient-Centred Equipment.
8. focus areas for developing content for the new hospitals:	
	– Organisational structure with the patients' needs in the centre – New forms of management – Boundaries and interactionwith the other parts of the healthcare sector – Emergency departments and organising acute treatment/care – Easy and quick access to diagnostics in hospitals – Workflows in operating rooms – Workflows in day clinics/outpatient clinics – Offices and mobile working stations

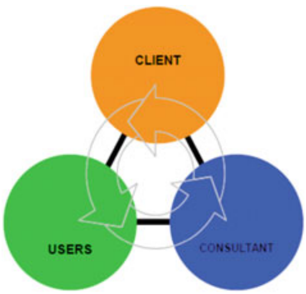
Source Office for Health and Social Politics, Danish Regions 2012

2. View—give people a view of the outside world.
3. Nature—enable contact with both indoors and outdoors.
4. Environment—provide both comfort and control (heat, light, sound, air).
5. Spatial legibility—makes people can understand places and can navigate.

The implementation on the New University Hospital Aarhus Project of an integrated approach to sustainability and evidence-based design has been facilitated by the adoption of a dialogue process involving the client group, users and consultants. The process defined twofold critical objectives to ensure successful project delivery: (1) Essential knowledge transfer from hospital organisation to the project and (2) Securing anchors and 'buy-in' or ownership within the hospital organisation of the aims and framework conditions of the project, its functional and technical solutions (Fig. 4.22).

In the Aarhus University Hospital Project, sustainability is implemented at all the various levels from town planning through to the design of individual building components and elements including their assemblies. Specifically, there is the use of innovative products based on their positive effect on the indoor climate. Selection of natural materials aims to ensure that a large amount of the materials used can be recycled and that the building components and assemblies are themselves based on recycled materials. Partial or complete visually stunning and durable wood cladding is the preferred solution for walls and surfaces in the public areas, such as the Forum, arcades and squares (Fig. 4.23).

Green roofs are incorporated in Aarhus University Hospital Project for their benefits of reducing heating cooling especially in summer, reducing the electromagnetic radiation that enters a building as well as reducing storm water run-off. This saves energy. Green roofs are used to filter pollutants and carbon dioxide out of the air to reduce airborne infections and diseases (e.g. asthma), filter pollutants and heavy metals out of the rainwater and insulate the building from noise, thereby mitigating the problem of increased use of paved surfaces or hard landscaping. The green roofs create a natural habitat that is of importance for the biodiversity of



Twofold objectives critical for project success

1. Essential knowledge transfer from hospital organisation to the project.
2. Securing anchors and ownership or 'buy-in' in the hospital organisation to the aims and framework conditions of the project, its functional and technical solutions.

Basis for Collaboration

1. Each part must establish a dedicated organisation and allocate sufficient resources.
2. Each part's role must be clearly defined and acknowledged.
3. The 3 organisations must mirror each other.
4. The weakest part sets and determines the pace of the process.

Fig. 4.22 New Aarhus University Hospital, Denmark—User dialogue process involved client, users and consultants (*Source* Møller 2012)

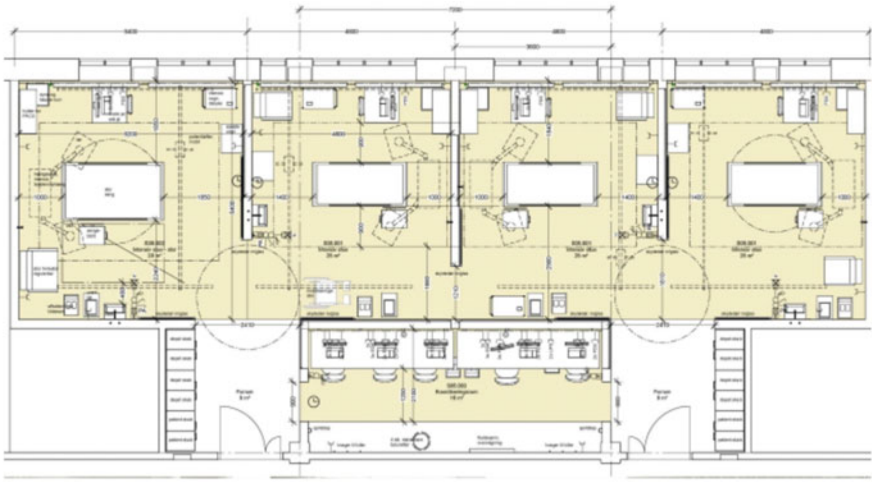


Fig. 4.23 New Aarhus University Hospital, Denmark—Staff areas: the vision is for equipment and fit-out design that combines advanced technology, attractive appearance with user-friendliness and good ergonomics to contribute to an improved working environment for the staff which reduces operational errors and work-related injuries (*Source* Møller 2012)

animal and plant species. Rather than views of concrete and asphalt the green space provided by the green roofs enhances views and experience of nature that helps to create a relaxing environment that reduces stress from the city.

Houghton Le Spring Primary Care Centre, Sunderland, South Tyne & Wear, UK

Completed in 2011, Houghton Le Spring Primary Care Centre was designed by P + HS Architects under a joint commission from Sunderland Teaching Primary

Care Trust and City of Sunderland Council. Houghton Le Spring Primary Care Centre represents the fourth development out of a set of 4 health primary care centres for Sunderland Teaching Primary Care Trust (1) Houghton Le Spring, (2) Washington, (3) Bunny Hill and (4) Grindon Lane) co-located adjacent to or integrated with leisure accommodation (School Sports Halls, Leisure Buildings) to facilitate easy and convenient access to leisure services by users. As the sixth healthcare project designed by P+HS Architects, for NHS South of Tyne & Wear, Houghton Le Spring Primary Care Centre learns from the experience of the other projects before it ((1) Houghton Le Spring, (2) Blaydon, (3) Wrekenton, (4) Grindon Lane, (5) Riverview and (6) Washington including many refurbishment health and social care schemes). Blaydon accommodates leisure facilities within the same building.

Houghton Le Spring Primary Care Centre's aims and objectives were to Extend the range of services available to patients; Bring care nearer to where patients live and work; Provide a catalyst for service modernisation; Facilitate reconfiguration of service delivery models; Provide opportunities for partnership working to promote public health; and Create 'nodes' of integrated health and social care services (Figs. 4.24, 4.25, 4.26, 4.38) (Table 4.5).

From inception, the design, construction and use of the Houghton Le Spring Primary Care Centre seeks to raise awareness of sustainability issues and to provide a positive image to the community, one that promotes sustainability through provision of a quality environment which applies and is supported by a variety of technologies.

1. *Improving health and social care in the local geographical area*: With financial restraint, public spending cutbacks, and an economic squeeze from rising fuel prices, stagnant property values, stalling salaries and low bank interest rates, how best to improve and sustain the delivery of care and support across a

Fig. 4.24 Houghton Le Spring Primary Care Centre—Main entrance (*Source* P + HS Architects 2012)

Fig. 4.25 Houghton Le Spring Primary Care Centre—Site plan (*Source* P + HS Architects 2012)

Table 4.5 Houghton Le Spring Primary Care Centre—Factsheet

Houghton Le Spring Primary Care Centre Development—Factsheet
Building description: Primary Care Centre comprising Minor Injuries Unit/Minor Surgery Suite, Diagnostics Suite [X-ray, Ultrasound and Echosound], Treatment Suite [Minor Operations, Treatment Room and Recovery], Planned Care Suite, 24 single bed/en suite Rehabilitation Unit, Community Cafe, Commercial Kitchen, Meeting Rooms, Physiotherapy Suite and Wellness Studio for therapies such as reducing toxity in ones' body Alongside, but integral to, the new healthcare facility are new and refurbished sports and leisure facilities, which include: New Entrance and Reception Area, New Dance Studio [former gymnasium] with sprung floor for exercise classes, New Wellness Studio equipped with treadmills, exercise bikes, rowing machines, resistance training machines and free weights area, New consulting rooms, New Multi-Use Games Area, Indoor bowling arena, Sports Hall and Changing rooms and showers
Size of the building: approximately 7,500 m^2 floor area, [5,600 m^2 Gross internal floor area]
Cost: £25 m, Cost per sq m: (25 m/7,500)
Construction method: Two storey steel-framed structure with sandstone masonry, 'Trespa Meton' cladding curtain wall envelope (Sandstone sourced locally from Stancliffe Stone [Origin: High Nick Quarry Hexham]; Polyester powder-coated aluminium framed double-glazed window/door systems; & aluminium shading or bri seloi)

(continued)

Table 4.5 (continued)

Houghton Le Spring Primary Care Centre Development—Factsheet
Procurement method: Scape Framework involving a deal to Design & Build a number of facilities. Scape Framework contractor Willmott Dixon used NEC [Option A] form of building contract
Design team: P&HS Architects, Cundall Structural Engineers, Mott MacDonald M&E Engineers, Breathing Buildings (R&D Engineer for the innovative Thermal Wall feature)
Contractor: Wilmott Dixon Construction Ltd from the Gateshead regional office. **Sub-contractor**: LJJ Contractors (M&E services—detailed design, implementation on site & commissioning)
Evidence-based architectural healthcare design features & interventions: Improve health and social care in the local geographical area including extending the range of services available to patients; Rehabilitation and enabling people to acquire skills for daily living that enhance autonomy and so that they can live more independently; Bring care nearer to where patients live and work; Provide a catalyst for health and social care service modernisation; Facilitate reconfiguration of service delivery models; Provide opportunities for partnership working to promote public health emphasising interrelationship between health outcomes such as heart disease, obesity and cancer with the environment including prevention, early detection, diagnosis and treatment; and Create 'nodes' of integrated health and social care services
Design features for sustainability: Implementing a number of integrated low-energy features in one building targeting BREEAM Healthcare 2008 'Outstanding' Rating (Energy Performance Certificate- EPC25) and with a BREEAM score of 86.3 % exceeded the required 85 % threshold for 'Outstanding':
1. A boiler system coupled to a 500 kWth ground source heat pump that serves the space heating and mechanical ventilation with the HWS system providing heating water to a plate heat exchanger. The bulk of under floor heating provided by the ground source heat pumps from approximately 200 bore holes across the site is complemented by wet radiators. Gas condensing boilers also supplement the ground source heat pumps
2. Thermal mass to provide passive cooling during summer. The 50-m-long thermal wall provides ventilation for the consultancy rooms as well as the open-plan waiting area and café. The wall is split into 49 individual shafts to separate the ventilation for individual spaces and therefore reduce the potential for infection transfer. In summer, the thermal wall is used to passively cool the incoming air. Cold air is drawn down the shafts into the wall during the night and the cooled shafts are then used to reduce the temperature of the warm outside air which is brought into the building the following day. In winter, a mixing ventilation strategy is used involving six unique e-stack units within the open plan areas and café. Cold air is bought into the buildings from outside and is diluted with interior warm air within the buildings before it reaches the occupants
3. The building envelope U-values were enhanced 20 % above the minimum requirements of UK Building Regulations Approved Document L and the air permeability rate was enhanced 40 % above the minimum requirements of Building Regulations Approved Document L
4. A 350 m^2 monocrystalline solar PV array mounted on the roof supplement the annual electrical usage, primarily providing power for heat pumps and air circulation fans. Roof mounted 10 m^2 solar thermal arrays to supplement domestic hot water requirements.
5. A 5.5kw wind turbine
7. Rainwater recycled to use for toilet flushing
6. Sedum roofing to increase biodiversity
Demonstration project that addresses micro-energy generation and energy use, the impact of transport and travel, raises awareness of sustainability and aims to engage the local community in the debate on sustainable lifestyles and behaviour. The project also implements Soft Landing Framework as indicated by Stage 3 Preparation for Handover, Stage 4 Initial Aftercare and Stage 5 Extended Aftercare for 2 years (1 year beyond the Defects Liability Period)

geographical health economy is a priority and one of the challenges facing healthcare providers, worldwide.

For use by patients who need more care and support than can be otherwise provided in their homes and who would usually be admitted to hospital, the £25 m Houghton Le Spring Primary Care Centre is part of the drive by NHS South Tyne & Wear to bring health and social care closer to people's homes where appropriate and prevent unnecessary hospital visits and admissions.

This is of importance to the client, Sunderland Teaching Primary Care Trust whose main activity is improving the health of local people and addressing equality access to high-quality health care; commissioning (or buying) the best hospital and community services; working to continually improve and develop the services provided by General Practitioners and their teams, by district nurses and health visitors and by pharmacists, dentists and optometrists; as well as developing excellence in learning across the Trust.

2. *Rehabilitation and Enabling people to acquire abilities ± skills for daily living so they can live more independently*: After traumatic events such as undergoing surgery and treatment patients are often ill-prepared to return back to their normal lives and must be rehabilitated to enable them to recuperate or to make the necessary adjustments in order to avoid rehospitalisation. The issue is determining where such rehabilitation is to take place specifically whether this is in a hospital or in the community ensuring that there is no 'treatment gap'. Key functions of community inpatient units and halfway hospitals cover 'step-down' from traditional acute ward, rehabilitation, integration into after-care prior to discharge, brief crisis interventions, brief assessments, initiation of change of medication and respite care (Boardman and Hodgson 2000).

Fig. 4.26 Houghton Le Spring Primary Care Centre—Model (*Source* P + HS Architects 2012)

From April 2013, the abolition of the Primary Care Trusts meant that The Intermediate Care Assessment and Rehabilitation Service of Gateshead Healthcare NHS Foundation Trust manage the £1.3 m annual services focusing on rehabilitation and enabling people to acquire skills for daily living to enhance autonomy and so that they can live more independently. Referrals for this facility provide comprehensive assessment, treatment and rehabilitation for men aged 18–65 who require specialist care to deal with complex needs.

In an environment with appropriate security, service users receive specialist care from experienced multi-disciplinary teams and enjoy excellent social, educational and leisure facilities. The main aim of the facility is to guide individuals through their care pathway, supporting them to take increasing responsibility for managing their own health and social needs. This leads to the ultimate goal of enabling them to live with the least restrictions, be that within their own units or by returning to their own communities (Figs. 4.27, 4.28, 4.29, 4.30, 4.39, 4.40, 4.41).

3. *Single Inpatient Rooms with ensuite bathrooms*: Universal room (an inpatient room accommodates patients at all levels of acuity) and the variable acuity nursing model (a nursing model of care designed to serve a patient population at all levels of acuity, from acute care to step-down to intensive care) have been propounded as innovative design solutions to enhance flexibility (Brown and Gallant 2006). With origins whose aim was to reduce patient transfers between units corresponding to change in acuity level, universal rooms and the variable acuity nursing model have gained popularity because these concepts offer latitude in patient allocation, staffing (assignment of nursing staff to patients in a particular care delivery model) and long-term adaptability to changes in patient population, acuity and census (Figs. 4.31, 4.32).

Fig. 4.27 Houghton Le Spring Primary Care Centre—Reception and waiting areas (*Source* P + HS Architects 2012). Many scientific studies now support the conclusion that natural daylight shortens patient recovery times, improves their mood and generally promotes health and well-being

Fig. 4.28 Houghton Le Spring Primary Care Centre—Central circulation hub: all common circulation areas look out over extensively landscaped parkland designed specifically to facilitate complementary therapeutic activities (*Source* P + HS Architects 2012)

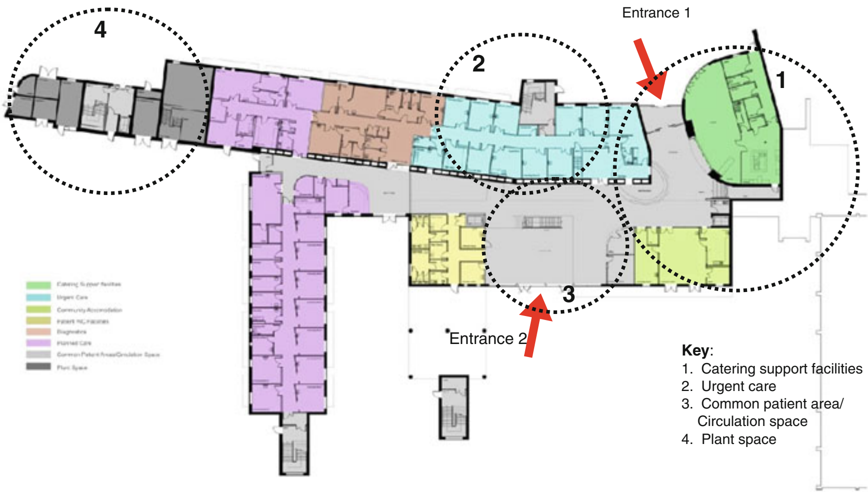


Fig. 4.29 Houghton Le Spring Primary Care Centre—Ground floor plan (*Source* P + HS Architects 2012)

A limited supply of beds in hospitals, increasing demands for acute care beds due to raising admissions exacerbated by an accumulation of 'longer stay' patients on acute wards who block further admissions are also an important driver for the provision of step-down inpatient bed accommodation at the Houghton Le Spring Primary Care Centre. A significant number of admissions could be avoided if suitable alternatives were available, and many patients with prolonged stays could

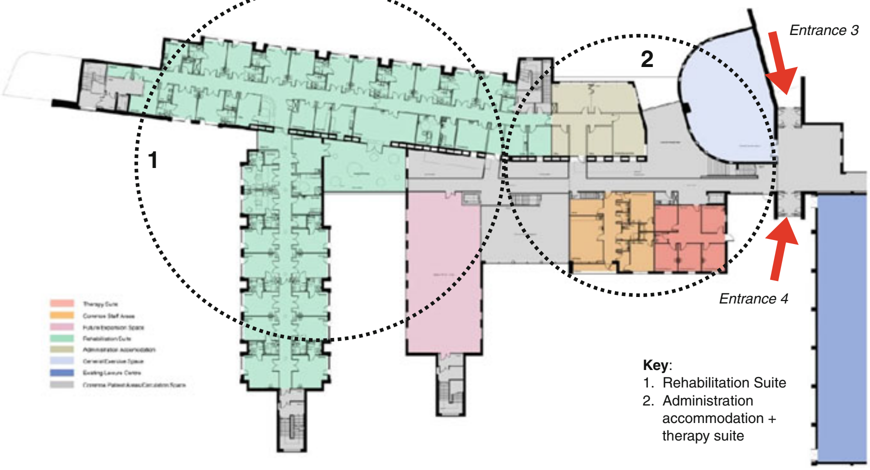


Fig. 4.30 Houghton Le Spring Primary Care Centre—First floor plan (*Source* P + HS Architects 2012)

Fig. 4.31 Houghton Le Spring Primary Care Centre—Typical single inpatient room: view towards the window (*Source* P + HS Architects 2012)

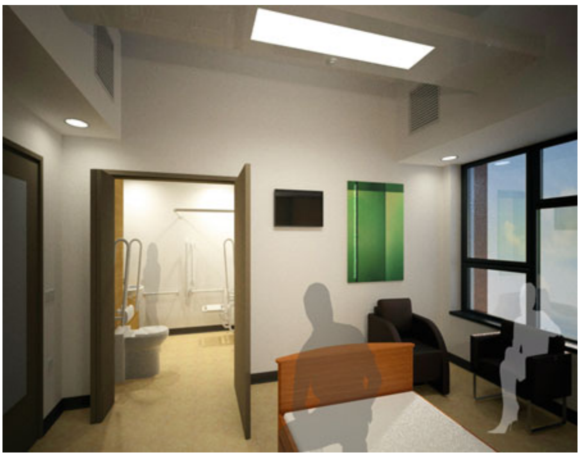


Fig. 4.32 Houghton Le Spring Primary Care Centre—Typical single inpatient room 2: view towards ensuite toilet (*Source* P + HS Architects 2012)

be discharged if appropriate community and residential options existed (Boardman and Hodgson 2000) (Figs. 4.31, 4.32)

At Houghton Le Spring Primary Care Centre, the 24 generously sized single inpatient rooms with ensuite bathrooms provide a step-down pre-discharge facility between the hospital and home. At 19 m^2 in floor area, the single inpatient room (excluding the 4.5 m^2 En-suite shower, WC and wash hand basin or 7.0 m^2 En-suite assisted shower, WC and wash hand basin) is greater than the recommended space allowance of 16 m^2 for single bedroom and 4.5 m^2 for En-suite indicated in UK Health Building Note 04 (Phiri 2004). The Centre provides care intermediate between that of an intensive care unit and a normally staffed inpatient unit. The step-down beds are accommodated in rooms that are planned similar to semi-private and private patient rooms with monitoring support and additional medical gases. The nurse station for these beds is sized to accommodate monitoring equipment (Figs. 4.31, 4.32).

4. *Providing Quality Internal Environment to Support the Health and Well-being of Occupants*: Research shows that creating comfortable environmental conditions and a pleasant atmosphere is essential to support the healing process. Every day the indoor air is polluted by the occupants (breathing, coughing, sneezing,…) and their activities (cooking, bathing, heating,…), by building products (paint, glue, varnish, …) and the interior (radon,…) and by all other sources which contribute to a poor indoor climate. Ventilation is required for the health of the occupants to minimise health problems (irritation of eyes, nose and throat, headache, sickness and other diseases) and other comfort problems (smells, condensation, moisture) due to humidity, CO_2 and various substances. It is also essential for the life cycle of the building materials and helps reduce energy costs. However, ventilation also needs to take into account the influence of external noise for example passing cars or busses, sound of airplanes and trains.

The brief or programme for the Houghton Le Spring Primary Care Centre building was extremely challenging and sought to maintain an interior temperature below 25 °C and to provide a low-carbon design solution. This indicated that the interior temperature is to remain below 25 °C, for all but 100 h per year in order to ensure that patients are kept comfortable and in well-ventilated conditions at all times. Traditionally, this is often achieved through a combination of mechanical ventilation and air conditioning. The objective of the design team here, however, was to create an innovative, low-carbon solution for summer cooling through the use of natural ventilation and thermal mass.

Many scientific studies now support the conclusion that natural daylight shortens patient recovery times, improves their mood and generally promotes well-being. Results have shown that the health of patients close to windows improves more quickly. It is a well known fact that Seasonal Affective Disorders (SAD and S-SAD), which are said to affect 20 % of the population due to a lack of natural daylight, are known to respond to the hormone serotonin, whose production is triggered by natural daylight. It is accepted that the elderly and infirm, suffer the most from SAD, mainly because they have difficulty getting out into the open air, especially in winter. The ability to pipe in natural light, particularly to areas where it is needed most, greatly benefits older people and immobile patients. At Houghton Le Spring Primary Care Centre, skylighting using Monodraught Sunpipes has been applied as a way to maximise the ingress of daylighting into spaces at the heart of the footprint. Monodraught Sunpipes achieve a much more effective daylighting solution than traditional rooflights because their super reflective tube intensifies and reflects natural daylight to deliver free outdoor light to the spaces below. It is estimated that a 300 mm diameter Sunpipe provides reading-quality diffused light over a 3 m distance from the ceiling and to an area of approximately 9 m^2.

5. *Providing Easy and Convenient Personal Control of the Physical Environment*: Studies have found that perceived control an individual has over various characteristics of their physical environment in terms of ability to personalise one's space, control over temperature, lighting, acoustics, ventilation, social contact and privacy is crucial to improving activity levels, happiness, satisfaction and well-being.

At Houghton Le Spring Primary Care Centre, enhanced personal control of the environment has been provided in the inpatient rooms and consulting rooms. Intelligent lighting controls were specified, including daylight compensation. Lighting control to the circulation areas is via presence detection Passive InfraRed sensors with the office/consultation rooms controlled via absence detection with local override facility. The main waiting areas are controlled centrally via reception. The atrium is wired via a central switching rack allowing a variety of different combinations of luminaires to be switched simultaneously within the Atrium. External lighting is via time clock and photocell arrangement to restrict switch on/off luminaires where the daylight is still adequate.

6. *Improving staff productivity*: Research shows that the work environment has a substantial effect on the productivity of workers with performance directly affected by the quality and suitability of such things as a healthy environment, adequate and correct type of workspace and its provisions in terms of furniture and fixtures, good communication and information technology tools.

At Houghton, Le Spring Primary Care Centre enhancing staff productivity has sought to improve morale and motivation of medical and nursing staff, working with specialists in physiotherapy, education, primary health care, social work and dietetics.

7. *Improving the management of drugs to reduce costs and waste*: A number of models have been incorporated in hospital design to provide bedside storage for medications. These have evolved from the 'nurse-server' concept featuring pass-through cabinets for supplies and medications; the operating model

involving medication supply delivery by pharmacists who stock the medication drawers from the outside of the room, while nurses access the locked drawer from the inside of the room; adding medication drawers to casework in the patient room, or as a pass-through; to mobile carts, often with computers or workstations on wheels, where lockable drawers can be added to store medications for all patients a nurse is assigned to.

Challenges to reduce UK healthcare spending on drugs have led to adoption of measures to improve access to and storage of drugs on the healthcare premises. One design feature implemented at Houghton Le Spring Primary Care Centre is the provision of drug cabinets in consulting rooms that are accessed from the corridors for replenishing supplies ensuring that drugs are used within the required dates. This reduces the amount of out of date drugs and thereby reduces disposals and waste. The high carbon footprint of pharmaceuticals is another reason to ensure the minimum wastage of drugs use. Minimal to zero storage in the room reduces traffic in and out of the room and in turn contamination of supplies. Also the just-in-time distribution of supplies and medication reduces storage space and travel distances.

8. *Prevention rather than Cure Promoting Public Health and Well-being*: A key challenge facing healthcare planners, engineers and other groups is how to design and develop new and existing communities to address the health and well-being including dietary or nutritional requirements, safety, and mobility of residents (Kerr et al. 2012). Contemporary design practices that emerged during the past fifty years have facilitated sedentary life styles and behaviours, for example, spending lots of time watching television and sitting, dependence on fast foods and alcohol, automobile travel which have increased ailments and health concerns such as heart disease, weight gain and obesity, metabolic syndrome, diabetes, cancer, depression and other diseases. These health concerns have also been associated with poor diets and lack of physical activity or exercise exacerbated by poor quality unsafe neighbourhoods that discourage walking and an absence of or inaccessible conveniently located facilities for both indoor and outdoor activities.

Numerous studies have shown many benefits of physical activity in the domains of physical, cognitive and emotional well-being including reduced morbidity and mortality, prevention and treatment of obesity, cardiovascular disease, osteoporosis, some forms of chronic pain, chronic obstructive pulmonary disease, high cholesterol, high blood pressure, some cancers, decreased risk of falls, recovery from functional limitations and help older people in living independently (Kerr et al. 2012). The US Department of Health and Human Services 2008 physical activity guidelines recommendations to help Americans aged 6 and older improve their health through physical activity are for children and adolescents 60 min (1 h) or more of physical activity daily and for adults 150 min (2 h and 30 min) of moderate intensity physical activity or 75 min (1 h and 15 min) of vigorous aerobic physical activity per week or an equivalent combination of moderate and vigorous intensity aerobic activity.

Research shows access to nature and outdoor activities heightens opportunities for social interaction, alleviates anxiety and depression, offers positive distractions and a free enriching experience that aids the healing process (Nordh et al. 2009; Van den Berg et al. 2007; Sherman et al. 2005; Varni et al. 2004; Taylor et al. 2001, 2002; Beauchemin and Hays 1996; Kaplan and Kaplan 1989; Ulrich 1984). Other studies have also shown gardening as a therapeutic intervention and cost-effective means of improving well-being (Gonzalez et al. 2010). Studies found dementia and stroke patients show improved mobility and dexterity, more confidence and improved skills from gardening activities (Rappe 2005).

The brief for Houghton Le Spring Primary Care Centre has been widened in scope beyond the provision of the building to include facilities that encourage outdoor activities, e.g., youth skateboard park, gardening area or 'allotments', outdoor sports and amenities to increase understanding in the community of the importance of good diets and nutrition including the benefits of eating locally grown produce. Sports and leisure facilities have been expanded to include a Multi-Use Games Area facility and Skateboard Park which operate seamlessly with an existing outdoor bowls green and refurbished sports hall and indoor bowls hall. The linking of the wellness studio with a well-equipped physiotherapy department allows physical exercise to be prescribed, monitored and managed for effectiveness in order to improve health outcomes. Although access to facilities is not as important to those who adopt physical activity on their own, those targeted by family physicians may be influenced by access (Petrella et al. 2008). The response or lack thereof to exercise interventions in those at risk may be influenced by proximity to both physical activity and unhealthy eating facilities. This evidence-based strategy to encourage individuals to appreciate and enjoy the outdoors, 'working on the allotments' and get back to nature is an alternative way of preventing disease and promoting autonomy and independent living, while at the same time, improving well-being. The strategy is important to both South Tyne & Wear NHS and Local Authority Health & Social Services for priorities such as Maternal and Child Health; Diabetes; Coronary Heart Disease (CHD); Referral Management and Prescribing.

9. *Design for Sustainability*: Houghton Le Spring Primary Care Centre Development takes a holistic approach to sustainability and is innovative in the healthcare sector in implementing a number of integrated low-energy features in one building:

    1. A boiler system coupled to a 500 kWth ground source heat pump that serves the space heating and mechanical ventilation with the HWS system providing heating water to a plate heat exchanger. The bulk of under floor heating provided by the ground source heat pumps from approximately 200 bore holes across the site is complemented by wet radiators. Gas condensing boilers also supplement the ground source heat pumps.

2. Thermal mass provides passive cooling during summer. The 50-m-long thermal wall provides ventilation for the consultancy rooms as well as the open-plan waiting area and café. The wall is split into 49 individual shafts to separate the ventilation for individual spaces and, therefore, reduce the potential for infection transfer. In summer, the thermal wall is used to passively cool the incoming air. Cold air is drawn down the shafts into the wall during the night, and the cooled shafts are then used to reduce the temperature of the warm outside air that is brought into the building the following day. In winter, a mixing ventilation strategy is used involving six unique e-stack units within the open plan areas and café. Cold air is bought into the buildings from outside and is diluted with interior warm air within the buildings before it reaches the occupants (Figs. 4.33, 4.34, 4.35, 4.37)
3. The building envelope U-values were enhanced 20 % above the minimum requirements of UK Building Regulations Approved Document L, and the air permeability rate was enhanced 40 % above the minimum requirements of Building Regulations Approved Document L. Air leakage is one of the most significant contributors to inefficiently heated buildings. Studies confirm that air leakage can account for up to half of all heat losses in modern buildings and reduce insulation performance by as much as 480 %.
4. A 350 m^2 monocrystalline solar Photovoltaics (PV) arrays mounted on the roof supplement the annual electrical usage, primarily providing power for heat pumps and air circulation fans. Roof mounted 10 m^2 solar thermal arrays also supplement domestic hot water requirements. Photovoltaic technology generates electricity from light (Fig. 4.36).
5. A 5.5 kw wind turbine.
6. Sedum roofing construction as a well-insulated waterproofing system that is able to increase biodiversity and reduce any negative effects on it.
7. Rainwater recycled to use for toilet flushing. The recovered water is suitably treated and routed to serve flushing toilets within the building.
8. Other considerations, e.g., heat recovery was considered for all ventilation systems (with the exception of catering) and implemented where appropriate (all air-handling systems are full fresh air). High-efficacy lighting was specified (Figs. 4.32, 4.33, 4.34, 4.35, Table 4.6).

The main aim of installing novel low-energy features was to achieve excellent green standards targeting BREEAM 2008 ‘Outstanding rating’ (Energy Performance Certificate—EPC 25) the first in the UK healthcare sector. The building design, therefore, adopted a holistic way to sustainability with features that address energy supply and demand, water management, a metering strategy that saw over 40 sub-meters installed for monitoring energy use, and a building that achieved a very good rating under the UK Building Regulations. All this usefully provides a scope for developing informing benchmarks for this new building type. The design involved a close collaboration between the client representative for Sunderland Teaching Primary Care Trust, Architects, Engineers, Research & Development

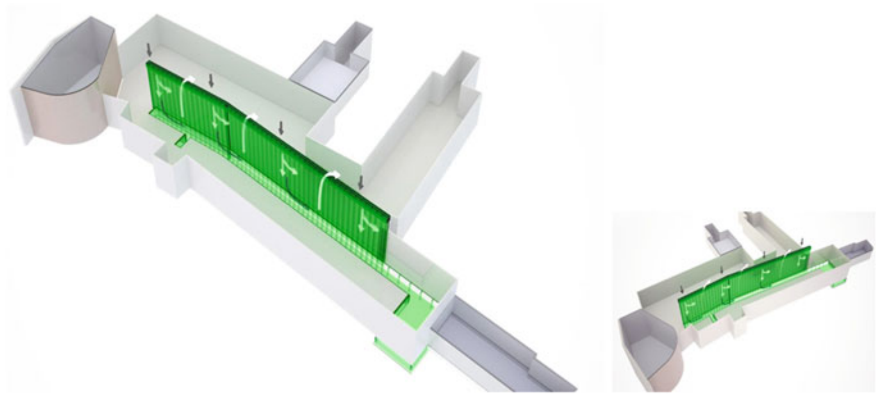


Fig. 4.33 Houghton Le Spring Primary Care Centre—Location of the ventilation spine (*Source* P + HS Architects 2012)

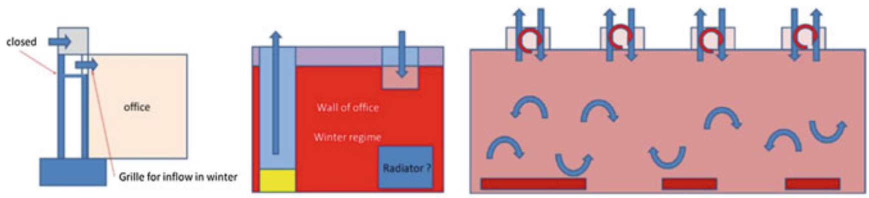


Fig. 4.34 Houghton Le Spring Primary Care Centre—Ventilation system (*Source* Breathing Buildings) WINTER: heat gains in public parts of the building will exceed heat losses whilst occupied due to high performing external building envelop. Excess heat is used to pre-heat cold external air and reduce demand for supplied heat. External cold air introduced at high level [6–7 m afgl] Incoming air falls mixing with rising warm air within the stack. Air movement encouraged by low wattage fans if necessary. The system is balanced via the Building Management System (BMS)

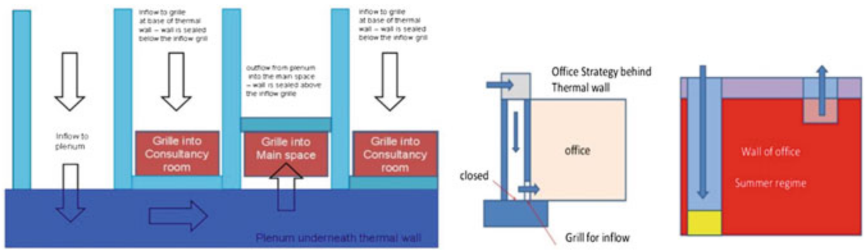


Fig. 4.35 Houghton Le Spring Primary Care Centre—Ventilation system 2 (*Source* Breathing buildings) SUMMER: warm external air is drawn into the building at high level and cooled via the subterranean plenum before circulation to the main public spaces. Incoming air supplied to consulting rooms does not pass through the plenum avoiding contamination risk. Exposed thermal mass within the plenum and adjoining rooms is used to cool incoming warm air. Night-time cooling of the plenum and thermal wall is the key to the summer operation recharging the cooling capacity for the following day

Table 4.6 Houghton Le Spring Primary Care Centre: technical details and specifications

Houghton Le Spring Primary Care Centre: Technical details and specifications	
Thermal wall: The central feature of the natural ventilation system extends along the spine of the entire building providing ventilation for the consultancy rooms and the open plan waiting area and café. The wall is split into a series of 49 individual shafts/chimneys which are used to separate the ventilation for the individual spaces and reduce the potential for infection and acoustic transfer – Number of chimneys: 49 – Size of chimneys: 1,060 × 460 mm – Area of chimneys: 0.46 m^2 – Height of chimneys: 9 m – Plenum dDimensions: 2,100 mm high × 2,000 mm wide – Material: 215 mm medium density concrete blockwork	**Natural ventilation** (to atrium and main waiting areas) uses an innovative low-energy system designed by *Breathing Buildings* – To optimise comfort and energy savings, different strategies are used in winter and summer. In summer, the thermal wall is used to passively cool the incoming air. The wall is cooled by drawing cold air down the shafts during the night and this is then used to cool the warm outside air brought into the building the following day. In winter, the consultancy rooms use mixing ventilation where air is brought in at high-level to each room. This provides an opportunity for dilution of the air as it descends which can reduce the requirement for pre-heating the incoming air – The waiting area and café use a series of e-stack ventilation units at high-level in conjunction with the thermal wall and additional low-level openings on the façade of the building. In summer, the system operates in up-flow displacement ventilation with outside air entering at low-level and hot air exiting through the e-stack units. In winter, the low-level openings are closed and ventilation is provided by the e-stack units where outside air is brought in and mixed with room air in a controlled manner before it reaches the occupants. This dilutes the cold air and can reduce the requirement for pre-heating in the same manner as with the consultancy rooms
Ground source heat pumps (providing heating in winter and cooling in summer) – Heat pumps: two, non-reversible – Number of boreholes: 104 – Depth of boreholes: 110 m – Diameter of boreholes: 150 mm – Output: 55° flow, 45° returns in winter. 6° flow, 12° return in summer. – Manufacturer: *CIAT* – Subcontractor: Ecovision	**Boilers** (only operate in the event of GSHP failure) – Fuel: natural gas – Type: fully modulating, high efficiency condensing boiler with low NOx emission – Heat output: 51–573 kW – Manufacturer: *Broag Gas 310 ECO* **Boilers** (Domestic hot water) – Fuel: Natural gas – Type: Wall mounted, high efficiency condensing boiler with low NOx emission – Manufacturer: *Broag Quinta Pro 115*

(continued)

Table 4.6 (continued)

Houghton Le Spring Primary Care Centre: Technical details and specifications	
Under floor heating – Product Ref: Tacker System – Insulation: 75 mm thick EPS polystyrene – Screed: 75 mm thick sand/cement – Manufacturer: *Warmafloor*	**Surface water attenuation** – Product: Twinstore tanks with integral flow regulator – Capacity: 470 m^3 – Outflow: 20 litres/second off-site – Manufacturer: *Tubosider*
Green roof – Area: 350 m^2 – Product: SarnaVert – Planting option: Sedum blanket, minimum 90 % coverage – Roof covering: Sarna PVC single ply membrane – Manufacturer: *Sarnafil*	**Rain water reclamation** (to serve WC flushing requirements) – Collector: GRP underground storage tank – Capacity: 12,000 l – Storage: 710 litre one-piece header tank – Manufacturer: *Stormsaver*
Solar thermal panels – Product Ref: DF100 – Description: High performance Direct Flow Vacuum Tube Collector – Area: 10 m^2 – Output: 5,000 kWh per year – Subcontractor: Photon Energy – Manufacturer: *Thermomax*	**Photovoltaic panels** – Product Ref: ND175 (E1F) – Description—High-performance photovoltaic modules made of polycrystalline silicon solar cells with module efficiencies of up to 13.3 % – Area: 270No PV modules of 994 × 1,318 mm, equating to 354 m^2 – Output: 35,200 kWh per year – Subcontractor: Photon Energy – Manufacturer: *Sharp*
Vertical Axis Wind Turbine – Rotor size: 5 m tall, 3.1 m diameter I Swept area 13.6m^2 I Mass 450 kg – Mast: 15 m tilt-down mast – Output: 5,000–11,000 kWh per year (site wind dependant) – Manufacturer: *Quiet Revolution Ltd.* **Energy performance** – Energy Performance Certificate (EPC) 25 – A [0–25] Energy Performance Asset Rating	**U-values** – Walls: 0.25 W/m^2k – Roof: 0.18 W/m^2k – Floor: 0.25 W/m^2k – Glazing: 1.6 W/m^2k **Air Permeability** – 4.3 m^3/(h.m^2) at 50 Pascals

Source P + HS Architects 2012

Engineers for the Thermal Wall, and SCAPE Framework Contractor who was also signed up to Soft Landing Framework (Tables 4.7, 4.8).

Houghton Le Spring Primary Care Centre project implemented a variety of measures to reduce unregulated emissions. These include compliance with both UK Department of Health and South Tyne & Wear NHS targets and strategy. Energy Performance Certificates (EPCs) are a mandatory requirement for all non-dwellings when they are constructed, sold or rented out. The EPC provides a rating of the potential energy efficiency and carbon emissions of a building, from A-G, known as the 'Asset Rating'. It is based on the theoretical consumption of energy

Table 4.7 Minimum levels set for all the 5 BREEAM 2008 classified ratings from a 'pass' to 'outstanding' show the onus increasing as the rating rises

<25 %	Unclassified	
>25 %	**Pass**	To gain a **Pass** (30 %) Rating Compulsory credits: – Management: Man 1—Commissioning – Health & Well-being: Hea 4—High-Frequency Lighting – Health & Well-being: Hea 12—Microbial Contamination
>40 %	**Good**	To gain a **Good** (45 %) Add Compulsory credits: – Water: Wat 1—Water Consumption – Water: Wat 2—Water Meter In NHS healthcare facilities achieving a 'Good' rating is mandatory for existing buildings at Outline of Business Case approval stage of a project
>55 %	**Very good**	To gain a **Very Good** (55 %) Rating Add Compulsory credits: – Energy: Ene 2- Sub-metering of Substantial Energy Uses – Land Use + Ecology: LE 4—Mitigating Ecological Impact
>70 %	**Excellent**	To gain a **Excellent** (70 %) Rating Add Compulsory credits: – Management: Man 2—Considerate Constructors – Management: Man 4—Building User Guide. – Energy: Ene 5—Low or Zero Carbon Technologies – Waste: Wst 3—Storage of Recyclable Waste – Plus in Energy: Ene 1 Reduction of CO_2 Emissions (i.e. an EPC (Energy Performance Certificate) of 40 of less for new build office) a minimum of 6 points must be awarded In NHS, healthcare facilities achieving an 'Excellent' rating is mandatory for new build at Outline of Business Case approval stage of a project
>85 %	**Outstanding**	To gain an **Outstanding** (>85 %) Rating in addition to all of the above (plus scoring 85 % or more) Add Compulsory credits: – Management: Man 2—Commissioning needs 2 points. – Management: Man 2—Considerate Constructors – Water: Wat 1—Water Consumption (Total available in Wat is 3). – Energy: Ene 1—Reduction of CO_2 Emissions—a minimum of 10 points must be awarded (i.e. an EPC of 25 of less for a new build office) BREEAM—In-Use-Certification within the first 3 years of operation is mandatory. This involves (a) Collecting user/occupier satisfaction, energy + water consumption data, (b) Using the data to maintain expected performance, (c) Setting reduction targets, monitoring water + energy consumption, and (d) Providing annual consumption & satisfaction data to the design team/developer and BRE. Also the building has to be published as a case study (written by BRE Global)

Note In addition, the building has to have a Post-Construction Review (before then this was not mandatory unless the client required them). It is also not possible to value engineer out the BREEAM features between the design and completion stages without getting penalised (or put another way being caught)

of the building and differs from the Display Energy Certificate (DEC) assessment, which uses actual energy consumption figures.

The UK Government published its Energy Review in 2002 in which it was recommended that renewables should contribute 20 % of energy generation by 2020, energy efficiency of buildings and transport should improve by 20 % by

Table 4.8 BREEAM Healthcare 2008 'outstanding' mandatory credits

	Credits	Description
Management—weighting 12.5 % (Encouraging the sustainable commissioning of the building, environmental management systems, staff education and training and purchasing)	Man 1 [2 credits]	*Commissioning*: Aim to recognise and encourage an appropriate level of building services commissioning that is carried out in a co-ordinated and comprehensive manner, thus ensuring optimum performance under actual occupancy conditions 1 Credit: Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice 2 Credit: Where, in addition to the above, evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post-construction (or post-fit-out)(Schedule of Evidence + Validation Statement)
	Man 2 [2 credits]	*Considerate Constructors*: Aim to recognise and encourage construction sites which are managed in an environmentally and socially considerate and accountable manner 1 Credit: Where evidence provided demonstrates that there is a commitment to comply with best practice site management principles 2 Credit: Where evidence provided demonstrates that there is a commitment to go beyond best practice site management principles (See Schedule of Evidence + Validation Statement)
	Man 4 [1 credit]	*Building User Guide*: Aim to recognise and encourage the provision of guidance for the non-technical building user so they can understand and operate the building efficiently 1 Credit: Where evidence provided demonstrates the provision of a simple guide that covers information relevant to the tenant/occupants and non-technical building manager on the operation and environmental performance of the building. (See Schedule of Evidence + Validation Statement)
Health & Well-being—15.0 % (Linking and consulting the community, sharing facilities, staff & patient empowerment)	Hea 4 [1 credit]	*High-Frequency Lighting*: Aim to reduce the risk of health problems related to the flicker of fluorescent lighting 1 Credit: Where evidence provided demonstrates that high-frequency ballasts are installed on all fluorescent and compact fluorescent lamps (See Schedule of Evidence + Validation Statement)
	Hea 12 [1 credit]	*Microbial Contamination*: Aim to ensure the building services are designed to reduce the risk of *legionellosis* in operation 1 Credit: Where evidence provided demonstrates that the risk of waterborne and airborne *Legionella* contamination has been minimised (See Schedule of Evidence + Validation Statement)

(continued)

Table 4.8 (continued)

	Credits	Description
Energy—weighting 19.0 % (Reducing carbon emissions, providing heating and lighting controls, energy monitoring and usage reduction facilities, use of daylight and alternative electricity tariffs)	Ene 1 [10 credits]	*Reduction of CO_2 Emissions*: Aim to recognise and encourage buildings that are designed to minimise the CO_2 emissions associated with their operational energy consumption 15 Credits: Where evidence provided demonstrates an improvement in the energy efficiency of the building's fabric and services and therefore achieves lower building operational related CO_2 emissions (See Schedule of Evidence + Validation Statement)
	Ene 2 [1 credit]	*Sub-metering of Substantial Energy Uses*: Aim to recognise and encourage the installation of energy sub-metering that facilitates the monitoring of in-use energy consumption 1 Credit: Where evidence provided demonstrates the provision of direct sub-metering of energy uses within the building 2 Credit: Where, in addition to the above, evidence provided demonstrates that sub meters are connected to a BMS or other type of automated control device. (Schedule of Evidence + Validation Statement: Over 40 sub-meters installed to facilitate data collection via half-hourly meter readings)
	Ene 5 [1 credit]	*Low or Zero Carbon Technologies*: Aim to reduce carbon emissions and atmospheric pollution by encouraging local energy generation from renewable sources to supply a significant proportion of the energy demand 1 Credit: Where evidence provided demonstrates that a feasibility study considering local (*on-site* and/or *near site*) low or zero carbon (LZC) technologies has been carried out and the results implemented 2 Credit: Where evidence provided demonstrates that the first credit has been achieved and there is a 10 % reduction in the building's CO2 emissions as a result of the installation of a feasible local LZC technology 3 Credit: Where evidence provided demonstrates that the first credit has been achieved and there is a 15 % reduction in the building's CO_2 emissions as a result of the installation of a feasible local LZC technology Alternatively 1 Credit: Where evidence provided demonstrates that a contract with an energy supplier is in place to provide sufficient electricity used within the assessed building/development to meet the above criteria from a 100 % renewable energy source. (Note: a standard Green Tariff will not comply) (See to Schedule of Evidence + Validation Statement)

(continued)

Table 4.8 (continued)

	Credits	Description
Transport—8.0 % (Reducing carbon emissions via provision of car parking, cyclist facilities, proximity to public transport facilities, distance –to-local amenities, green transport plan and compliance with controls assurance)		
Water—6.0 % (Minimising water consumption through leak detection, water use monitoring, low flush toilets and grey water recycling)	Wat 1 [2 credits]	*Water Consumption*: Aim to minimise the consumption of potable water in sanitary applications by encouraging the use of low water use fittings 3 Credit: Where evidence provided demonstrates that the specification includes taps, WCs, Urinals and showers that consume less portable water in use than standard specifications for the same type of fittings (Schedule of Evidence + Validation Statement)
	Wat 2 [1 credit]	*Water Meter*: Aim to ensure water consumption can be monitored and managed and therefore encourage reductions in water consumption 1 Credit: Where evidence provided demonstrates that a water meter with a pulsed output will be installed on the mains supply to each building/unit (Schedule of Evidence + Validation Statement)
Materials—12.5 % (Using materials from sustainable sources, prohibition of hazardous substances) BRE's Green Book Live + Green Guide to Specification provide useful information which make it more likely to achieve these credits (and the environmental benefit)		
Waste—7.5 % (Reducing waste, recycling and waste stream analysis)	Wst 3 [1 credit]	*Recyclable Waste Storage*: Aim To recognise the provision of dedicated storage facilities for a building's operational-related recyclable waste streams, so that such waste is diverted from landfill or incineration 1 Credit: Where a central, dedicated space is provided for the storage of the building's recyclable waste streams (Schedule of Evidence + Validation Statement)
Land Use + Ecology—10.0 % (Protecting ecological features and introducing natural habitats, re-use of sites and ecological enhancement)		
Pollution—10.0 % (Monitoring and addressing pollution, NO_x emissions, ozone-depleting substances, noise pollution and incineration practices)		
Innovation—9.0 % (Providing additional recognition for a procurement strategy, design feature, management process or technological development that innovates sustainability, above and beyond the level that is currently recognised and rewarded within standard BREEAM issues)		

2010 and that carbon dioxide emissions should be reduced by 60 % by 2050. These were broadly accepted in the 2003 Energy White Paper and translated into planning policy in Planning Policy Statement 22 (PPS22): Renewable Energy 2004, which planning authorities had to consider when preparing local development documents and when taking planning decisions. The PPS22 has been has been superseded by the National Planning Policy Framework 2012 whose goal is to reform and make the planning system in England less complex and more accessible, protect the environment and promote sustainable growth (Fig. 4.36).

The Department of Health's mandatory NHS Energy Efficiency Targets for NHS bodies were set in 2001 to achieve (Table 4.9):

1. A further 15 % reduction in energy consumption by 2010 (the NHS had achieved a 20 % reduction since 1990).
2. A target of 33–35 GJ/100 m^3 energy efficiency performance, for the health care estate, for all new developments, major redevelopments and refurbishments and
3. A target of 55–65 GJ/100 m^3 for all existing facilities.

Houghton Le Spring Primary Care Centre aims to find out how much electricity, gas and heat are used via a strategy for collecting data using actual meter readings rather than estimated readings that attract uplift. Over 40 sub-meters have been installed to facilitate data collection via half-hourly meters. Mains water meters at the boundary of the site at each incoming point of the building and cold fill connection for the rainwater harvesting system.

Fig. 4.36 Houghton Le Spring Primary Care Centre—Roof-mounted solar pre-heater arrays (*Source* P + HS Architects 2012). Advantages of building-integrated PV are enhancement of building appearance, solar gain control, thermal insulation, roof or façade material replacement, passive ventilation and electricity generation

Table 4.9 NHS England additional contributors to carbon reductions

Emissions sector	Proposed NHS/government intervention (additional to existing measures)	Potential reduction in carbon emissions
Procurement	Reduce unused pharmaceuticals	−0.53 $MtCO_2$ (−2.4 %)
	Smart/lean procurement of medical equipment	−0.19 $MtCO_2$ (−0.8 %)
	Smart/lean procurement of other expenditure	−0.38 $MtCO_2$ (−1.7 %)
Building energy	Onsite renewable electricity	−0.53 $MtCO_2$ (−2.4 %)
	Widespread measures to reduce electricity consumption	−0.27 $MtCO_2$ (−1.2 %)
	Increased Combined Heat and Power (CHP) to maximum potential by 2020	−0.35 $MtCO_2$ (−1.6 %)
Travel	Full implementation of smart travel plans across NHS estates. (Travel is responsible for 18 % of NHS carbon footprint)	−0.36 $MtCO_2$ (−1.6 %)
Cross-sector	UK Government meets EU renewable target via electricity target 35–40 %	−1.46 $MtCO_2$ (−6.9 %)

Source NHS England Carbon Emissions: Carbon Footprint Study 2008

10. *Supporting Evidence-Based Design*: An appropriate evidence-based design process that facilitates decision-making to improve quality of the staff and patient care environment is integral to generate the necessary rigorously collected robust, reliable and the latest available evidence.

Houghton Le Spring Primary Care Centre Project represents two vital aspects of how relevant an appropriate process that supports evidence-based architectural healthcare design is and ought to be. The first aspect acknowledges organisational learning especially of innovative design interventions from previous projects, from project-to-project as well as from other sectors. In practice, this has meant for example, Houghton Le Spring Primary Care Centre adopts a different environmental system from that for Blaydon Primary Care Centre, Gateshead in which about 10 % of the thermal energy provided by a biomass boiler unit integrated into the central heating system with a fuel store located adjacent to the boiler installation and complemented by a small-scale combined heat and power (CHP) unit (high efficiency gas-fired plant) which is operated asynchronously with 'grid electricity' to reduce the quantity of bought-in electrical energy (Figs. 4.37, 4.38 and 4.39).

The other aspect is the need to involve users in the delivery of health and social care clearly establishing the role of the physical environment in order to ensure that there is not only joined up thinking about issues, such as sustainability but also recognising that positive health outcomes are only achievable with the corporation and collaboration of patients, staff and visitors. UK NHS buildings consume over

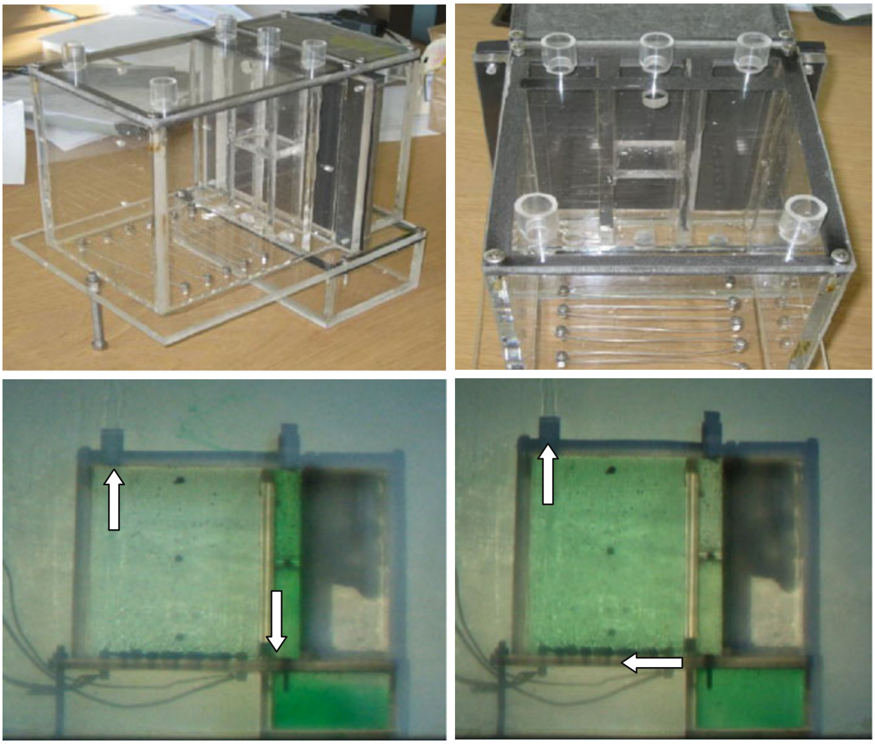


Fig. 4.37 Houghton Le Spring Primary Care Centre—Ventilation system laboratory testing of the physical models (*Source* Breathing buildings)

£410 million worth of energy and produce 3.7million tonnes of CO_2 every year (NHS England Carbon Emissions Study 2008). Energy use contributes 22 % of the total NHS carbon footprint and offers these savings to be directly reinvested into further reductions in carbon emissions and improved patient care. People are increasingly aware of the need to reduce energy consumption at home and it is important the NHS educates, encourages and enables staff to do the same at work. From the start, South Tyne & Wear NHS has been acutely aware that it has to increase public understanding and comprehension of the use of renewable sources in the building as a key component of meeting primary objectives of, for example, making reductions to carbon emissions and at the same time reducing health inequalities. This means clear communication on the obligation of all staff about energy conservation and impact of service activities on their own and South Tyne & Wear NHS's carbon foot print.

Fig. 4.38 Houghton Le Spring Primary Care Centre—Main entrance elevation: the double height main entrance to the facility provides café and catering facilities with potential for external terraced areas, community accommodation and an education centre equipped with health education reference material and web access via pc's for use by all visitors. Materials for the elevations have been chosen from the point of view of: local resourcing including the external facing brickwork, stonework and joinery; green credentials (i.e. no impact upon global warming criteria) and robustness (*Source* P + HS Architects 2012)

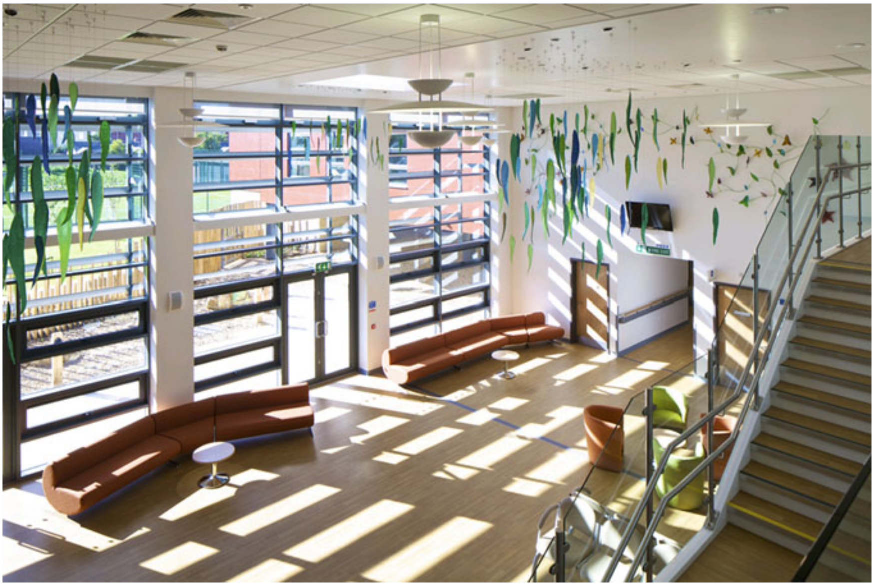


Fig. 4.39 Houghton Le Spring Primary Care Centre—Waiting area: the double height main entrance to the facility provides café and catering facilities with potential for external terraced areas (*Source* P + HS Architects 2012)

Lessons from Houghton Le Spring Primary Care Centre

A major lesson from the implementation of an approach to Design for Sustainability coupled with evidence-based design in the Houghton Le Spring Primary Care Centre project highlights the importance of high aspirations and determination by the client, Sunderland Teaching Primary Care Trust.

Houghton Le Spring Primary Care Centre's aims and objectives (Extend the range of services available to patients; bring care nearer to where patients live and work; provide a catalyst for service modernisation; facilitate reconfiguration of service delivery models; provide opportunities for partnership working around health promotion; and create 'nodes' of services to reinforce communities) validate the architects' 10 guiding principles for sustainable healthcare buildings:

1. Integrate with the local environment and promote regeneration.
2. Meet the needs of and provide facilities for local communities.
3. Provide accessible transport options for all members of the community.
4. Deliver cleaner, greener and safer public spaces that are rich in biodiversity.
5. Use resources (energy and water) efficiently.
6. Provide flexibility and adaptability to meet changing service needs.
7. Consider whole life performance, including long-term asset value.
8. Provide a quality internal environment to support the health and well-being of users.
9. Use materials that reduce adverse environmental and health impacts.
10. Reduce pollution and waste to avoid negative health and other impacts.

Houghton Le Spring Primary Care Centre Project is important in raising issues associated with the risks of adopting innovative renewable technologies, which then require the development and implementation of appropriate risk management measures and policies. In this case, these include the Thermal Wall that runs along the spine of the building and is used to provide passive cooling during summer and the exposed Thermal Mass to ceilings of consulting rooms designed to be cooled at night by ventilation when the exterior air is cool. Precast concrete soffits have been incorporated into the design to contribute to the building's thermal mass. Exposed concrete slabs and a high-density internal thermal wall exploit the thermal mass providing passive cooling during summer. The building envelope U-values were enhanced 20 % above the minimum requirements of UK Building Regulations Approved Document L and the air permeability rate was enhanced 40 % above the minimum requirements of Approved Document L.

Notwithstanding the commitment of an enlightened client willing to adopt innovative design strategies with aspirations of exemplary environmental standards such as those demanded by the BREEAM 'Outstanding' Rating, a more fundamental issue of affordability remains. While justification for implementing these in Houghton Le Spring Primary Care Centre is evident in the potential social benefits, return on investment needs to be demonstrated.

Houghton Le Spring Primary Care Centre Project poses an important challenge for health and social care providers specifically the need to be vigilant and ensure measures are adopted that reconcile the Supply Side perspective with the Demand Side experience. The problem is that all this takes time (Table 4.10).

Another lesson from Houghton Le Spring Primary Care Centre is associated with the above issue—the project addresses Post-Completion and Early Occupation Stages of a project, i.e., Soft Landing Framework Stage 3. Preparation for Handover, Stage 4. Initial Aftercare and Stage 5. Extended Aftercare as of vital significance to clients with rolling building programmes while at the same time indicating the relevance to obtain crucial feedback of a variety of evaluations—fabric performance evaluation, energy performance appraisal, occupancy perception and satisfaction survey.

On the application of BREEAM Healthcare on the Houghton Le Spring Primary Care Centre Project, a number of key drivers are validated:

1. *Legislation and Planning*: for example, some local planning authorities require BREEAM pre-assessments and increasingly, accreditation including Section 106 Agreements. Other than being relevant to UK policies, climatic environment and CIBSE (Chartered Institution of Building Services Engineers) guidance, the judging criteria for BREEAM Healthcare also keeps pace with legislative developments and current best practice.
2. *Public Sector Organisations*: for example, a minimum BREEAM rating for all new buildings and refurbishments has been in place since 2006 (UK Department of Health, Office of Government Commerce, Homes & Communities Agency and Department of Education).
   Specifically, the Department of Health requires achieving a BREEAM Healthcare 'Good' rating (>45 %) mandatory for existing buildings at Outline of Business Case approval stage of a project while a BREEAM 'Excellent' rating (>70 %) is mandatory for new build at Outline of Business Case

Table 4.10 Reconciling the supply side perspective with the demand side experience: a challenge for healthcare providers

The Supply Side Perspective	The Demand Side Experience
• Green technology = low energy • Green icons = good media coverage, happy authorities, *green awards!* • Assumptions that all inputs will lead to beneficial outputs and emergent properties • Locked into misleading perspective that green is, by definition, virtuous or righteous • Failure to see and plan for unintended consequences of technologies • Perspective becomes locked, designers blind or go into denial of green shortcomings	• Green in appearance, but not in practice • Gap between theory and practice • Occupants can hate them: poor usability, underperforming controls, conflicts (e.g. daylight versus lighting controls), lack of flexibility, poor commissioning and handover • Manual operation deficient, auto operation no sensical • Unexpected own goals (too much technology, too much management required) and unaligned aims and objectives • Settings that do not improve healthcare outcomes • Dissatisfied occupants and operators

approval stage of a project. All this has helped embed BREEAM Healthcare into UK planning and building system.

3. *Private Sector Organisations*: for example, some developers have set voluntary minimum BREEAM ratings for all new buildings (e.g. British Land and Land Securities). A must for organisations in our new sustainably aware society, multi-national companies are keen to publicly display their green credentials and to show that every part of their business is green, including their buildings.
4. *Quantitative thresholds* rather than percentages: for example, BREEAM's minimum standards (relating to specific credits or specific criteria for credits) are tiered based on the target rating, ranging from 4 to 26 credits.
5. *Assessor involvement* (rather than team involvement) but involves design, construction and management teams and an accredited professional (AP): BREEAM has trained licensed assessors who assess the evidence against the set credit criteria and report it to the BRE, who validate the assessment and then issue the Certificate. Since its origins BREEAM has expanded massively, going from a 19-page BRE Report with 27 Credits, to a massive 350-page Technical Guide (for the Office Version) with some 105 Credits. Assessor involvement is an advantage for BREEAM in that an assessor can work with BRE to develop assessment criteria specially tailored to a building where it does not fit neatly into of the existing schemes.
6. *Based on Carbon Dioxide*: for example, BREEAM encourages reduction in CO_2 to zero net emissions in relation to English Building Regulations Part L 2010 to achieve maximum points worth 10.56 % of the total score.

Rationale and justification for Houghton Le Spring Primary Care Centre is provided by the need to respond to developments in the way health and social care is delivered (Department of Planning Transport and Infrastructure (DPTI) Publications 2012; Department for Communities & Local Government 2012; Office of the Deputy Prime Minister (Department for Communities & Local Government since May 2006) 2004). The changing face of medicine means that more conditions are now best treated by specialist teams. Specialist teams need to see a certain number of cases to be safe and increasing numbers of cases treated often add to their effectiveness. In order to provide this specialist service in a consistent and reliable way 24 h a day, 7 days a week, there is a need for a critical mass of consultants and other staff in a single facility. There is also an increasing need for specialist equipment to support the specialist teams. This is the rationale for the need for specialist centres with a large catchment area than the traditional district general hospital. In general, the more complex and the less common a condition, the more likely it is to benefit for specialist care. There is evidence in some conditions that the disadvantages and risks of extra travelling time to a specialist centre are outweighed by the advantages of specialist care. The ambulance service also has an increasing diagnosis and treatment role so that the longer journey is not a therapeutic vacuum but treatment can be started at home or before arrival at hospital (SDO Project 08/1304/063) (Figs. 4.42, 4.43).

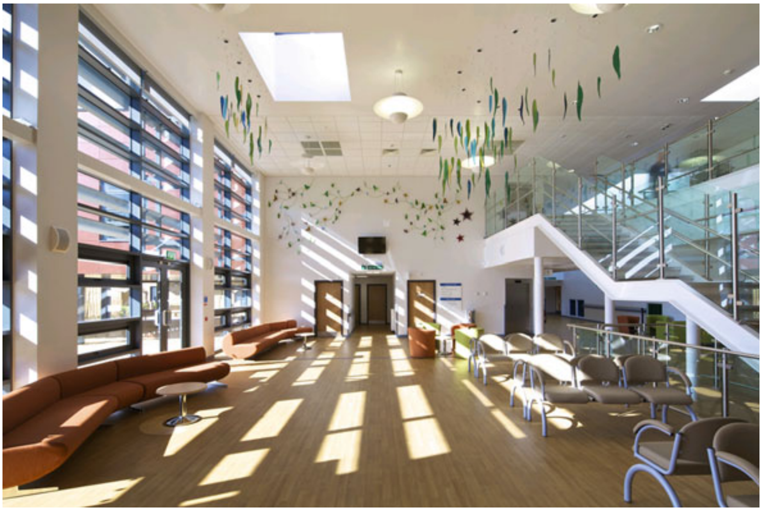


Fig. 4.40 Houghton Le Spring Primary Care Centre—Waiting area 2: the double height main entrance to the facility provides café and catering facilities with potential for external terraced areas (*Source* P + HS Architects 2012)

Fig. 4.41 Houghton Le Spring Primary Care Centre—Corridor: colour is applied to aid navigation and wayfinding (*Source* P + HS Architects 2012)

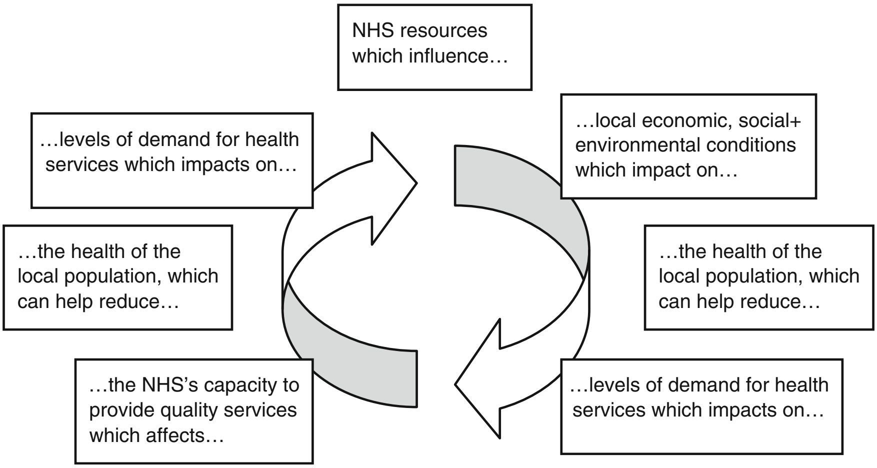


Fig. 4.42 Houghton Le Spring Primary Care Centre—The need for a virtuous circle (*Source* The NHS Good Corporate Citizenship Assessment Model 2006). How the NHS behaves can make a big difference to people's health and to the well-being of society, the economy and the environment. Behaving as a good corporate citizen can save money, benefit population health and can help reduce health inequalities. Carbon literacy, carbon numeracy and carbon governance need to be taken as seriously as similar responsibilities towards financial probity and patient safety

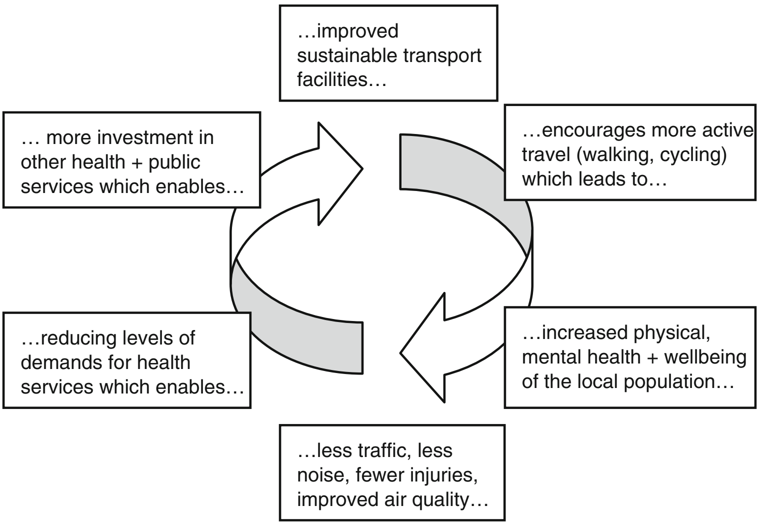


Fig. 4.43 Houghton Le Spring Primary Care Centre—Virtuous circle for NHS travel (*Source* The NHS Good Corporate Citizenship Assessment Model 2006)

New Parkland Hospital, Dallas, Texas, USA

The Parkland Health & Hospital System Project, Dallas County, Texas, is located in a $1.27 billion (8 billion CNY) healthcare campus. The project involves replacing the existing extensively reconfigured and remodelled 54-year-old Parkland Memorial Hospital, which was failing to provide a safe, welcoming, patient-centred healing environment. HDR Architecture, partnered with another Dallas-based team, Corgan Associates are the Architects for the new 862-bed, full service, acute care, replacement hospital (Figs. 4.44, 4.45, 4.46) (Table 4.11).

The Parkland Campus is located within the Southwestern Medical District and Parkland serves as the primary teaching hospital for the University of Texas-Southwestern Medical Center.

The project is being funded, in part, by a $747 million (4,708.33 million CNY) bond programme and a $150 million (945.45 million CNY) fundraising campaign that includes funds raised from private sector benefactors. Due also to the public bond financing, Parkland Administration sought to select a design team with strong ties and connection to the local community.

Fig. 4.44 Parkland Hospital Dallas, USA—Aerial view (*Source* HDR + Corgan 2012)

Fig. 4.45 Parkland Hospital Dallas, USA—Landmark view (*Source* HDR + Corgan 2012)

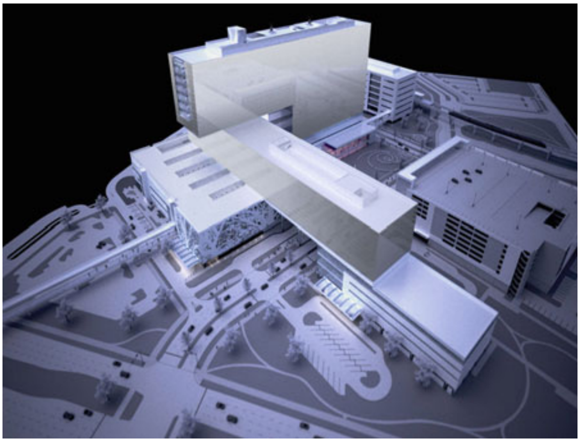


Fig. 4.46 Parkland Hospital Dallas, USA—Model (*Source* HDR + Corgan 2012)

Acknowledging the link between the physical environment and patient and staff outcomes, the architects have implemented a strategy, based on integrating sustainability and evidence-based design to translate the project vision into a meaningful and financially sound design and construction plan. The goal of the new building is to provide patients with the best possible diagnostics and medical treatments, in a caring, compassionate environment that also ensures good working conditions for staff.

To successfully implement evidence-based design principles, the New Parkland Hospital Design Team adopted an approach that sought to create an environment of care that incorporates streamlined processes, new technologies, and nurturing design elements. A ‘visioning’ session, involving all project stakeholders, was

Fig. 4.47 Parkland Hospital Dallas, USA—Inpatient room. The size of the dedicated family space single inpatient rooms is generous, allowing for rooming-in capability. An example of patient-centred design in which spaces are sized appropriately to accommodate not only patients, but their families and caregivers teaming at the bedside. (*Source* HDR + Corgan 2012)

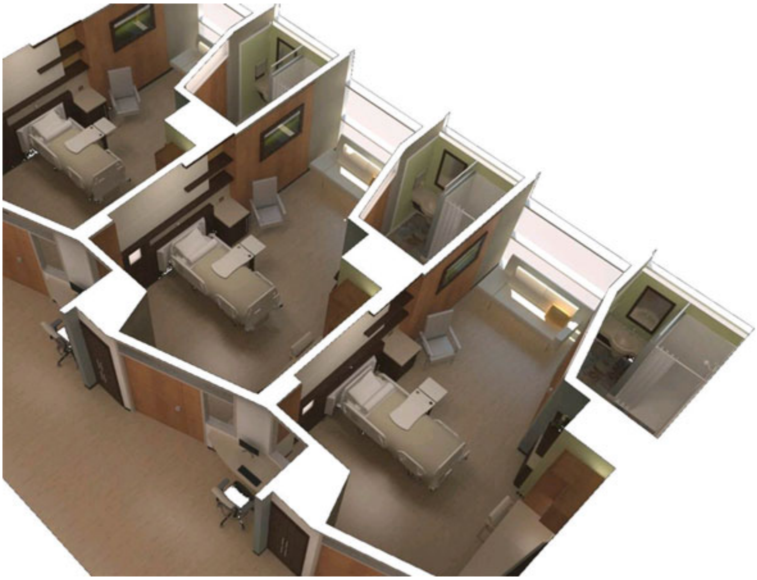


Fig. 4.48 Parkland Hospital Dallas, USA—To promote patient safety, same-handed inpatient rooms (isometric), which feature an identical, repeated layout are used so that the patient bed, technology, caregiver space; family space, washroom, and handwashing sink are in the same location in every patient room (*Source* HDR + Corgan 2012)

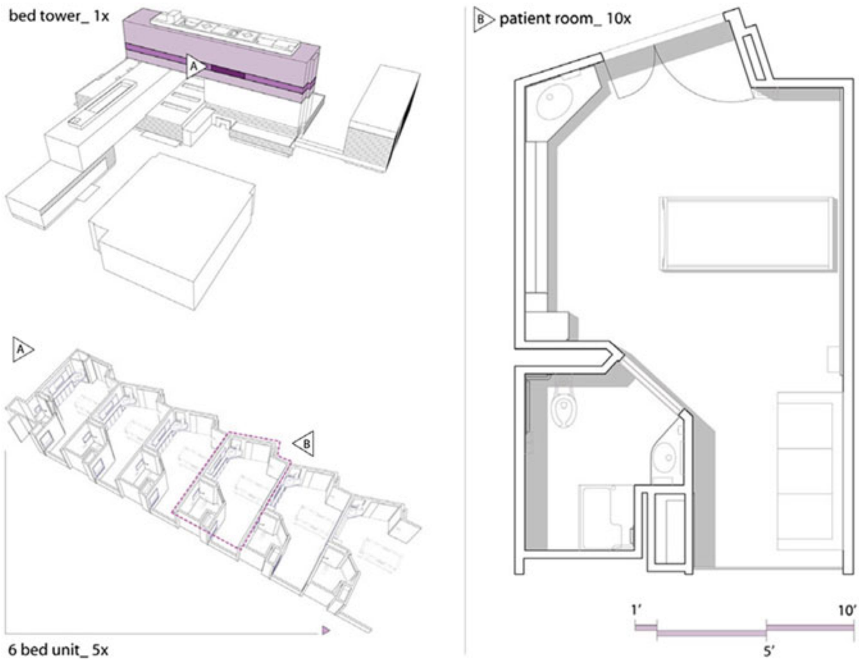


Fig. 4.49 Parkland Hospital Dallas, USA—To promote patient safety, same-handed inpatient rooms, which feature an identical, repeated layout are used so that the patient bed, technology, caregiver space; family space, washroom, and handwashing sink are in the same location in every patient room. (*Source* HDR + Corgan 2012) Same-handed rooms also reduce sound transmission through separating the headwalls and by separating the patient doorways

used to identify proven, evidence-based strategies and corresponding interventions that would then improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family and staff satisfaction while accommodating today's best practices. This includes ensuring flexibility to adapt to future demands as a vital key element.

1. *Improving patient safety*: Slip-resistant flooring is specified, especially in large and ADA (Americans with Disability Act 1990) compliant patient bathrooms to reduce patient trips, falls and injuries (Becker et al. 2003; Brandis 1999). Walk-in showers are provided without curbs or up stands, design features which are likely to cause a patient to trip or stumble. To assist caregivers when moving patients, there are clear, unobstructed pathways to rest rooms. Furthermore, night lights are specified in patient rooms and bathrooms to decrease opportunities for falls. Patient lifts aid vertical movements within the building.
   The provision of all single inpatient rooms help to reduce the risk of hospital-acquired nosocomial infections (Ben-Abraham et al. 2002; McManus et al. 1992). Highly visible and ample hand sanitisers are placed throughout the facility with a caregiver sink conveniently installed at the entrance to each

Table 4.11 Parkland Hospital Dallas, USA—Factsheet

Parkland Hospital Dallas, USA—Factsheet
Project type: Academic Medical Centre, Acute Care Hospital, Ambulatory Care Facility, Campus Master Plan, Women's Centre. The process ensures the appropriate gathering of data and invaluable clinical input from mock-ups or true-to-size models of patient care areas including rooms for patients, operating, intensive care examination, trauma, labour and delivery suite, visitor elevators, neonatal intensive care and emergency examinations. Regular meetings of the patient and family advisory committee and the design team are used to test new ideas and define best practices in the eyes of the patient. Once clinical and patient input is integrated into the rooms, nursing staff return to practise mock medical codes and procedures in the mock-up rooms to validate that the design is functioning at its highest level. In so doing, the process reassures nurses and clinical staff that the design team is looking out for their patient care needs
Project components: Cardiology, Dining Area/Café, Emergency Department, Gynaecology and Obstetrics, Imaging, Inpatient Beds, Intensive Care Unit, Labour-Delivery-Recovery (LDR), Neonatal Intensive Care Unit (NICU), Nursery, Oncology, Outpatient Clinic, Parking, Paediatric, Pharmacy, Physical Therapy, Radiology, Reception/Lobby, Rehabilitation, Research, Surgery (inpatient), Wellness Centre
Type of construction: New Construction
Size: 176,515 m^2 (1,900,000 SF), a 17-storey main hospital building with 862 inpatient rooms
Costs: Costs-, Cost per m^2 -
Professional Services: Architecture, Charrette, Engineering, Healthcare Consulting, Master Planning, Programme Validation, Site Design, Strategic Consulting
Project team: Client—Parkland's Facilities Planning & Development Department, Architect—HDR + Corgan, Construction Manager—BARA (Joint venture firms include Dallas-based Balfour Beatty Construction, Austin Commercial, Azteca Enterprises and the Dallas office of Atlanta, Georgia-based H. J. Russell & Company), Programme Controls Manager—CH_2 M HILL (a programme management, construction management and design firm)
Evidence-based architectural healthcare design features: Identifying and implementing proven evidence-based strategies and corresponding interventions that improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family, and staff satisfaction while accommodating today's best practices, with flexibility to adapt to the future
Sustainable features: Daylighting and Views, Energy Efficiency, LEED™ Registered with a goal of LEED™ Silver Certification, Low-Emitting Materials, Public Transportation Access and a facility that is designed to be visitor and staff-friendly, with clear pathways, multi-level parking, private inpatient rooms and a wellness park accessible through the hospital itself, Water-Efficient Landscaping

Source HDR + Corgan 2012

room (Kaplan and McGuckin 1986). The use of HEPA (high-efficiency particle attenuation) filtration systems in patient rooms, emergency exam rooms, and other zones help protect the most vulnerable patients, while the specification and installation of antimicrobial flooring and fabrics reduce the spread of germs (Crimi et al. 2006; Jiang et al. 2003; Hahn et al. 2002). HEPA provision prevents airborne infection and provides a constantly monitored, positive airflow pressure system to push bacteria and other micro-organisms out of the room and keep clean air in (Figs. 4.47, 4.48, 4.49, 4.50, 4.58).

2. *Improving patient outcomes*: Parkland's inpatient units feature decentralised caregiver workstations between every two patient rooms, as well as visual access

into each room, which increases observation capabilities and allows for a higher level of care. Supplies and equipment are decentralised to the patient room, thereby reducing the amount of time the caregiver spends on fetching supplies and equipment and enabling more time on direct care (Zborowsky et al. 2010) Bedside barcoding and a bedside computer terminal increase staff efficiencies.

Acuity-adaptable patient rooms are provided for all areas (ICU, medical/surgical, postpartum, rehabilitation, and mental health). Universal, acuity-adaptable, variable acuity and transitional care are terms used interchangeably to describe a patient care model concept. This concept supports the position that the patient remains in the same room for the duration of their stay and the staffing level is adjusted according to the acuity of the patient.

Acuity-adaptable rooms are used because evidence demonstrates they reduce transfers of patients, result in fewer handoffs between caregiver teams (limit treatment delays and opportunity for errors), eliminate delays for the placement of patients, reduce the need for equipment duplication, reduce complications, and decrease a patient's length of stay (Hendrich et al. 2004). Hospitals with acuity-adaptable patient rooms also report fewer staff injuries resulting from transferring patients. A dedicated family area provided in each patient room encourages family members to participate in the caregiving process, allowing continuity of care once the patient is discharged. This addresses the problem of shortage of caregivers, while leading to better outcomes because the family understands how to better care for loved ones (Figs. 4.47, 4.48, 4.49, 4.50, 4.58).

3. *Increasing patient, family, and staff satisfaction*: Environmental noise control is implemented to increase the satisfaction of patients, visitors, and staff and importantly to reduce stress. For example, extensive use of 'on-stage/off-stage' design features defines separate corridors and elevators for visitors and staff. This lessens foot traffic and, along with sound attenuation between rooms, significantly reduces noise in patient care areas, ultimately promoting a more peaceful healing environment (Donahue 2009; Trites et al. 1970). Finishes are chosen for the sound-absorbing qualities (MacLeod et al. 2007; Hagerman et al. 2005).

Fig. 4.50 Parkland Hospital Dallas, USA—Inpatient units feature decentralised caregiver workstations between every two patient rooms thereby providing visual access into each room, which increases observation capabilities and allows for a higher level of care. (*Source* HDR + Corgan 2012)

The size of dedicated family space, single inpatient rooms is generous, allowing for 'rooming-in' capability, which allows for overnight stays by family members or friends. This space is located nearest the window and away from the entrance to the room thus ensuring staff members have clear access to the patient from the hallway. Caregiver space inside the patient room is between the doorway and the patient bed. This fosters enhanced privacy for the patient because caregivers face the patient and the family when discussing care and do not face the door.

Individual temperature control allows patients to control the comfort level within their own room (Williams and Irurita 2005). Soft lighting and soothing artwork alleviates restlessness and provides suitable distractions that lessen dependence on medications. High-end furnishings foster an inviting, homelike atmosphere. Several studies have shown that views of nature are significantly effective in promoting recovery by decreasing depression, lessening agitation, and promoting sleep cycles and quality of sleep (Beauchemin and Hays 1996; Ulrich 1984). There is increasing evidence that exposure to nature is especially beneficial in fostering restoration for stressed patients, family members and staff.

As a result, Parkland's patient rooms have large windows for unobstructed natural views and an abundance of sunlight (Baird and Bell 1995). Large windows in staff work areas and procedure rooms strengthen the connection with the outside world. A design that encourages connection with the outdoors creates a healing environment that promotes landscaped outdoor therapy. Patients, guests and staff have access to well-designed landscaped gardens that provide calming, pleasant views of nature, fostering access to social support and privacy while providing opportunities for escape from stressful clinical settings (Ottosson and Grahn 2005; Tennessen and Cimprich 1995; Cimprich 1993). Many healthcare employees will be able to use healing gardens as a restorative escape from work stress. Twenty minutes in a park setting has been shown to be sufficient to elevate attention performance, relative to the same amount of time in other settings (Taylor and Kuo 2009). In a large survey of residents in nine Swedish towns and cities, Grahn and Stigsdotter (2003) found that, when asked what they would recommend to a friend who was feeling stressed and worried, most respondents gave the first rank to taking a walk in the forest, an aspect which offered opportunities for 'clearing the head' (Figs. 4.51, 4.52, 4.53, 4.56, 4.57).

Based on research, post-occupancy evaluations, and other feedback, Parkland's gardens are designed to provide a variety of types of spaces for different user groups, with privacy from others and views from the building (Nordh et al. 2009; Van den Berg et al. 2007; Sherman et al. 2005; Varni et al. 2004; Taylor et al. 2001, 2002; Kaplan and Kaplan 1989). Some areas accommodate groups, while others are dedicated to private contemplation. A looping and easily navigable circulation pattern provides opportunities for exercise with a wide variety of plants and water features affording positive distractions (Figs. 4.53, 4.54, 4.55).

4. *Improving efficiency and effectiveness of staff*: Healing environments not only contribute to patient well-being, but also to the well-being of the physicians, nurses, facilities staff and administrators who work in the building (Moorthy et al. 2003). These positive work environments contribute greatly to improved

staff recruitment and retention—two critical factors that mitigate against labour shortages in the healthcare sector.

To promote patient safety, same-handed rooms that feature an identical, repeated layout are used, so that the patient bed, technology, caregiver space, family space, washroom and handwashing sink are in the same location in every patient room (Pati et al. 2010). The decision to provide all same-handed patient rooms was supported by a teleconference held with staff from other hospitals with same-handed rooms. The existing users reported that staff found same-handed rooms easier to work in because there is less confusion about where equipment is located, something which is especially important during crisis situations when staff from various areas converge in one place to handle emergencies. The ease of orienting float staff, residents, and medical students who are on a particular unit for one day to six weeks and then rotate somewhere is an advantage. Two managers mentioned that same-handed rooms that are easy to navigate and work in is advantageous in terms of recruiting and retaining staff.

Same-handed rooms are provided for emergency department examination, labour and delivery and surgery suites. Each patient floor accommodates two 36-bed units, built end-to-end with nursing alcoves tucked along the 300-foot-long hallways. No centralised nurses' stations are located in patient units, while de-centralised stations mean less walking for staff. Each unit has team rooms for collaborative care discussions and a relaxing lounge for staff interaction and rest.

Fig. 4.51 Parkland Hospital Dallas, USA—Well-designed landscaped gardens provide calming and pleasant nature views and easy access to outdoors (*Source* HDR + Corgan 2012)

Fig. 4.52 Parkland Hospital Dallas, USA—Lighting study (*Source* HDR + Corgan 2012)

5. *Accommodating today's best practices, with flexibility to adapt to the future*: The difficulties of predicting what the future of health care will be five years from now, let alone 50 years because of constant and rapid advances in medical diagnostics and treatment modalities, along with their associated technologies mean that hospitals must be flexible to grow and change to meet the future medical needs of communities and also have the capability to adapt to these changes efficiently and with minimal investment. By designing flexibility through the provision of modular units and acuity-adaptable rooms, designers and planners have, to a certain extent, been able to accommodate this need.
6. *Design for Sustainability*: This is implemented through LEED™ Healthcare registration + commitment and through the use green building methods and energy sources, as well as specifications of environmentally friendly building materials. This means adopting measures to reduce indoor pollutants including the use of paints, adhesives and other materials that emit little or no volatile organic chemicals, e.g., formaldehyde. Distinguishing sustainability features for the hospital project are Public Transportation Access, Daylighting and Views, Energy and Water Efficiency, Low-Emitting Materials, Landscaping and LEED™ Healthcare registration (Fig. 4.55).

In 2005, the Senior Vice President for Parkland Memorial Hospital explained 'to qualify as green, the new hospital must meet certain basic requirements such as, during construction phase reducing the amount of buildings materials hauled to landfills and, once it's operating, using 20 % less water than a typical building of its size. The rules also require the recycling of certain building materials, including paper, corrugated cardboard, glass, plastics and metal. And the operators of a green building must look for ways to reduce energy consumption to lower energy costs….The new Parkland would have to amass 50–59 points on the LEED scale to reach the silver rank. For example, if the new hospital provides secure bike racks within 200 feet of its entrance and gives its employees a place to shower and change clothes, the hospital earns one point. If it provides preferred parking for certain fuel-efficient cars, it gets another point. And just being located within a half-mile of a new DART rail stop will get the hospital six points for encouraging alternative transportation (Tables 4.12, 4.13)'.

New Parkland Hospital is registered for LEED™ Healthcare, a joint initiative between the Green Guide for Health Care and US Green Building Council. The project therefore uses the hierarchical organisational structure as based on that for the LEED™ Rating System for New Construction. In this case, credits are awarded to seven sections: 'Sustainable Sites' (18 %), 'Water efficiency' (9 %), 'Energy and Atmosphere' (39 %), 'Materials and Resources' (16 %), 'Indoor Environmental Quality' (18 %), 'Innovation in Design' (6 %) and 'Regional Priority' (4 %), adding up to a total of 110 %. LEED ™ Healthcare rating or degrees of performance are Certified (40–49 %), Silver (50–59 %), Gold (60–79 %) and Platinum (80+) giving an overall score of up to 110 (Tables 4.12, 4.13).

7. *Proven strategies and associated design interventions alone are inadequate for successful implementation but must be supported by an evidence-based design process*: Although it is not uncommon for those working on hospital projects to request the advice of medical professionals and patients, a unique Nurse Liaison Team ensures every detail of this large project is focused on patient care.

Fig. 4.53 Parkland Hospital Dallas, USA—Gardens are designed to provide a variety of types of spaces for different user groups, with privacy from others and views from the building (*Source* HDR + Corgan 2012)

Table 4.12 Mandatory prerequisites for all LEED ratings (Certified 40–49 points; Silver 50–59 points; Gold 60–79 points; Platinum >80 points)

Environmental Category Total Weighting = 100 % Max. points 110.0	Credit Descriptions
Sustainable Sites Weighting 23.6 % Maximum points 26.0	SSP1—*construction activity pollution prevention*:
Water efficiency Weighting 9.1 % Maximum points 10.0	WE1—*Water use reduction: Aims for water use reduction in irrigation*
Energy & atmosphere Weighting 31.9 % Maximum points 35.0	EAP1—*Fundamental commissioning of building energy systems*: EAP2—*Minimum energy performance*: Requires the building to be designed to ASHRAE 90.1 without the need to specifically require technologies or design solutions EAP3—*Fundamental refrigerant management*: Relates to refrigeration
Materials & resources Weighting 12.7 % Maximum points 14.0	MRP1—*Storage and collection of recyclables*: Aims for appropriate storage for recyclable waste with a focus on rewarding recycling rather than merely reducing waste in the first place
Indoor environmental quality Weighting 13.6 % Maximum points 15.0	EQP1—*Minimum indoor air quality performance* EQP2—*Environmental tobacco smoke (ETS) control*
Innovation in design Weighting 5.5 % Maximum points 6.0	
Regional priority Weighting 3.6 % Maximum points 4.0	

Fig. 4.54 Parkland Hospital Dallas, USA—A looping and easily navigable circulation pattern provide opportunities for exercise and access to a wide variety of design features (plants, textures and water elements) affording positive distractions. Extensive use of 'on-stage/ off-stage' design features identify separate corridors and elevators for visitors and staff (*Source* HDR + Corgan 2012)

This process ensures the appropriate gathering of data and invaluable clinical input from mock-ups or true-to-size models of patient care areas including rooms for patients, operating, intensive care examination, trauma, labour and delivery

Table 4.13 Parkland Hospital LEED ™ Healthcare registration with a goal of silver certification (50–59 %) mandatory credits

	Design target credits	Description
1. Energy and atmosphere (39 %)	Use on-site renewable energy systems, such as solar, wind and geothermal strategies to offset fossil fuel energy uses (1–7 points) Located within a half-mile of public transportation, such as a light rail station (6 points) Give preferred parking for fuel-efficient cars (1 point)	'Environmental site assessment'
2. Indoor environmental quality (18 %)	Supply daylight levels of light to 75 % or more of the occupied areas of the building (1 point)	'Integrated project planning and design' 'Acoustic environment'
3. Innovation in design (6 %)	Provide secure bike racks within 200 yards of the building entrance and provide showers and changing facilities for riders (1 point)	'Resource use—design for flexibility'
4. Materials and resources (16 %)	Use low-emitting adhesives and sealants in flooring (1 point) Recycle or salvage non-hazardous construction and demolition debris (1–2 points)	'Low-emitting materials', 'PBT source reduction— mercury in lamps/lead, cadmium and copper', 'Furniture and medical furnishings'
5. Regional priority (4 %)	Install permanent monitoring systems to ensure ventilation maintains minimum requirements (1 point)	'Community contaminant prevention—airborne releases'
6. Sustainable sites (18 %)	Provide shade from existing trees for 50 % of the site's hard surfaces, including roads, sidewalks, courtyards and parking lots (1 point)	'Connection to the natural world—places of respite/direct access for patients'
7. Water efficiency (9 %)	Use less water than the amount calculated for the building, not including irrigation (2–4 points)	'Water use reduction—measurement &verification/building equipment/cooling towers/food waste systems' 'Minimise portable water use for medical equipment'
Total of 110 %	**LEED™ Registered with a goal of Silver Certification (50–59 %)**	

suite, visitor elevators, neonatal intensive care and emergency examinations. Regular meetings of the patient and family advisory committee and the design team are used to test new ideas and define best practices in the eyes of the patient. Once clinical and patient input is integrated into the rooms, nursing staff return to practise mock medical codes and procedures in the mock-up rooms to validate that the design is functioning at its highest level. In doing so, the process that facilitates the patient-centred approach reassures nurses and clinical staff that the design team is looking out for their patient care needs.

Fig. 4.55 Parkland Hospital Dallas, USA—Provision of well-designed and naturally lit spaces for socialisation and waiting increases patient, family and staff satisfaction. (*Source* HDR + Corgan 2012). Leather et al. 2003 compared two waiting areas in terms of their effects on the environmental appraisals, self-reported stress and arousal, satisfaction ratings and pulse readings of 145 outpatients and found that a nouveau waiting area was associated with more positive environmental appraisals, improved mood, altered physiological state, and greater reported satisfaction

Centre for Health Design's Pebble Project Research Initiative also provides examples of healthcare organisations whose facility designs have made a difference in the quality of care—as well as financial performance. As a Pebble Project Partner, the Parkland Hospital Case Study is mined for data and evidence to demonstrate that the design can improve the quality of care for patients; attract more patients; recruit and retain staff; increase philanthropic, community, and corporate support; and enhance operational efficiency and productivity.

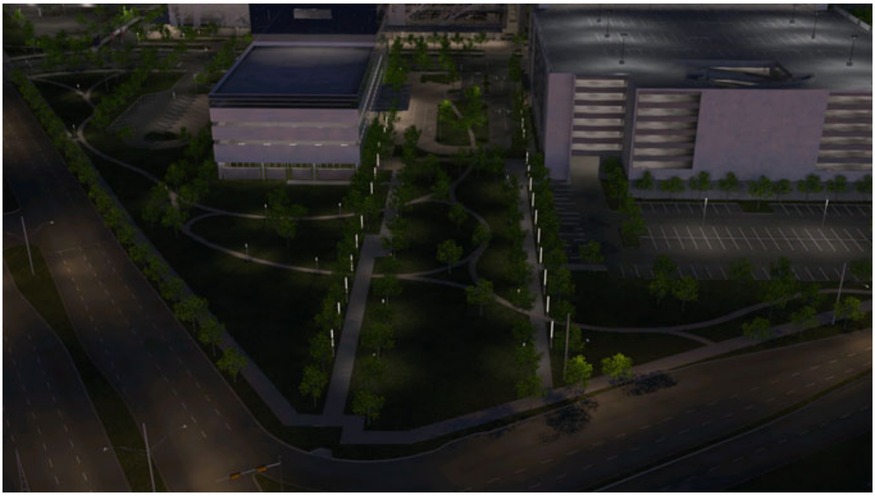


Fig. 4.56 Parkland Hospital Dallas, USA—Lighting studies 2. (*Source* HDR + Corgan 2012)

Fig. 4.57 Parkland Hospital Dallas, USA—Lighting studies 3. (*Source* HDR + Corgan 2012)

Lessons from New Parkland Hospital, Dallas, USA

Acknowledging the link between the physical environment and patient and staff outcomes, the New Parkland Hospital Design Team implemented a strategy based on integrating sustainability and evidence-based design to translate the project vision into a meaningful and financially sound design and construction plan. The threefold objectives for the evidence-based design are:

Objective 1: Improve patients safety through environmental measures

1.1 Reduce Healthcare-Acquired Infections
1.2 Reduce Medical Errors

Objective 2: Improve patients' outcomes through environmental measures

2.1 Reduce Pain
2.2 Improve Patients' Sleep
2.3 Reduce Patients' Stress
2.4 Reduce Depression
2.5 Reduce Spatial Disorientation
2.6 Improve Patients' Privacy + Confidentiality
2.7 Foster Social Support

Objective 3: Improve staff outcomes through environmental measures

3.1 Reduce Staff Stress
3.2 Improve Staff Effectiveness

These relate to the evidence-based design innovations as advocated in the Fable Hospital (Sadler et al. 2011). First published in 2004, the Fable Analysis showed that carefully selected design innovations, though they may cost more initially, could return the incremental investment in one year by reducing operating costs and increasing revenues. However, the payback for the Fable 2.0 investment should occur within three years, longer than the one year estimated for the original Fable hospital but still a reasonable return by any business standard. A primary factor in the longer payback period is that financial calculations no longer include increased revenue projections (Tables 4.14, 4.15).

From the outset, proven evidence-based strategies and corresponding interventions are identified for the New Parkland Hospital to improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family and staff satisfaction while accommodating today's best practices, with flexibility to adapt to the future. New Parkland Hospital validates the importance and relevance of the key underlying factors for the evidence-based strategies and interventions in order to provide a healthcare environment that fosters healing, efficiency and effectiveness:

1. Privacy Dignity and Company—allow people to control how and when they share space.
2. View—give people a view of the outside world.
3. Nature—enable contact with both indoors and outdoors.
4. Environment—provide both comfort and control (heat, light, sound, air).
5. Spatial legibility—make places people understand and can navigate.

Sustainability is implemented through LEED™ Healthcare registration with a goal for Silver Certification (50–59 % rating). The architectural practice is committed to quality design and sustainable architecture, a trailblazing approach that has seen the firm become the first practice in Texas to construct and showcase its own LEED™ Silver certified building. Implementation is also shown through the use of green building methods and energy sources, as well as environmentally friendly building materials, products and green operations. With the rising demand to meet new standards, healthcare planners and designers are specifying materials and components for ironmongery, balustrades and railings, fittings and fixtures that can aid the process of fighting infection. Antimicrobial copper surfaces are the only such class of materials registered with the Environmental Protection Agency to continuously kill more than 99.9 % of certain disease-causing bacteria within two hours including MRSA and VRE (Tables 4.14, 4.15).

Notwithstanding this, to achieve the goal of Silver Certification New Parkland Hospital needs to score highly under the 'Energy and Atmosphere' heading which constitutes 39 % credits. Public Transportation Access enhances New Parkland Hospital's sustainability credentials by providing a means to address transportation, one of the main sources responsible for a significant proportion of world energy usage, raw material consumption and CO_2 emissions.

Identifying proven strategies and associated design interventions alone is inadequate for successful implementation of an integrated approach to sustainability and evidence-based design but must be supported by an appropriate evidence-based design process that facilitates decision-making to improve quality of the staff and patient care environment. Such a process needs to based on rigorously

Table 4.14 Evidence-based design innovations supported by research in peer-reviewed journals

Evidence-based design innovations supported by research in peer-reviewed journals
1. *Large single-patient rooms* improve clinical outcomes by reducing hospital-acquired infections, adverse drug events and falls. They also improve patient satisfaction. Increasing room size by 100 ft^2 allows family members to stay overnight with the patient, increasing their satisfaction and involvement in care
2. *Acuity-adaptable rooms* reduce patient transfers, thereby avoiding diagnostic and treatment service delays, reducing medication errors and patient falls, reducing staff work load and increasing patient satisfaction
3. *Larger windows* increase provision of natural light and enlarge views offering opportunities for enhanced calming effect essential for patient recovery and improved outcomes including benefits for hospital staff
4. *Larger patient bathrooms* with Double-Door Access help staff or family members assist patients moving to and from the bed and the bathroom to reduce or eliminate patient falls most which occur between the bed and the bathroom or in the bathroom itself
5. *Ceiling-mounted patient lifts rooms* reduces staff back injuries caused by lifting patients in and out of bed or a bathroom, staff sickness and absence, and hospital costs while increasing compliance with safety legislation
6. *Enhanced indoor air quality* includes HEPA filtration which is 99.97 % effective in removing harmful particulates to reduce health care-associated infections. Infections can be reduced further if outside air is exhausted after a single use, rather than re-circulated
7. *Decentralised nursing substations* (Alcoves) allow nurses to see into the patients' rooms and respond to problems more quickly thereby help reduce patient falls and allow nurses to spend more time in direct patient care
8. *Hand-hygiene facilities* via conveniently located and easily accessible sinks in all patient rooms and other points of care helps increase hand washing compliance, the most important measure for preventing the spread of pathogens
9. *Medication area task lighting* reduces medication-dispensing errors because clinicians can easily read medication labels and prescriptions more accurately
10. *Noise reducing measures* involve multiple strategies to quieten the building and deal with noise a common problem for patients and staff, causing patients sleep deprivation, slower recovery, and increased stress. These strategies include provision of high-performance sound-absorbing acoustical ceiling tiles, carpeting where possible, sound-absorbing finishes, noise and vibration-isolated mechanical rooms, wireless pagers, space for private discussion, reduced alarm sounds, and single-patient rooms
11. *Energy demand reduction* is possible through a high-efficiency building envelope and glazing, high-efficiency mechanical equipment, and heat recovery systems
12. *Water demand reduction* is achievable by implementing measures like low-flow fixtures, rainwater harvesting or capture, and high-efficiency food service equipment
13. *e-ICU comprehensive remote ICU monitoring capability* through the use of e-ICU has reduced mortality rates, shortened the average ICU stay and reduced costs
14. *Healing art* that depicts calming views of nature can reduce anxiety and depression to speed recovery
15. *Positive distraction measures* (including art, sculpture, calming music) can play an integral role in the patient healing process to speed recovery and decrease patients' pain, length of stay, stress and depression
16. *Healing gardens* reduce stress and improve outcomes by providing positive distraction and restorative nature contact for patients, families and staff

Source Sadler et al. 2011

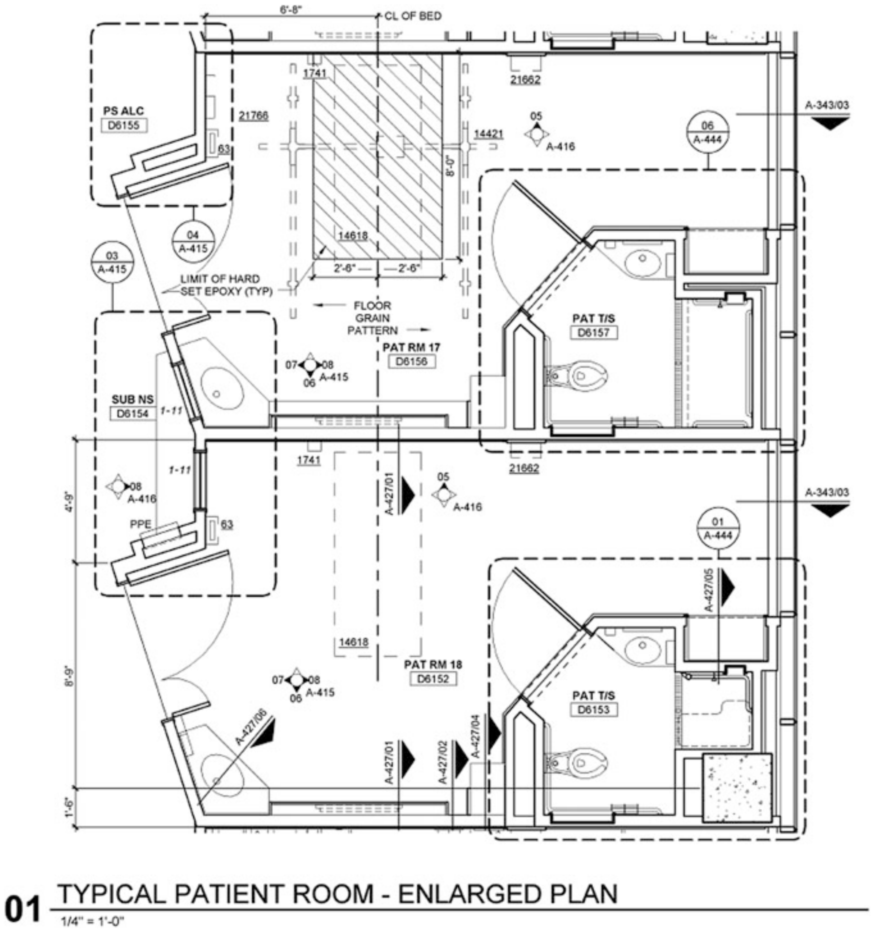


Fig. 4.58 Parkland Hospital Dallas, USA—Typical inpatient room layout (*Source* HDR + Corgan 2012)

collected robust, reliable and the latest available evidence. This means the designer effectively using research during the iterative design of a project benefitting decision-making through feedback. This is not just about gathering data at the beginning of a project but about infusing design decisions with data-driven insights and observations throughout the entire process

Table 4.15 LEED 2009 credit descriptions

Environmental Category Total Weighting = 100 % Max. pts. 110	Credit Descriptions
Sustainable sites Weighting 23.6 % Max. points 26.0	SSP1—*Construction Activity Pollution Prevention*: 1 Point per Credit
	SS1—*Site Selection*: 1 Point per Credit
	SS2—Development Density and Community Connectivity: 5 Points per Credit
	SS3—*Brownfield Redevelopment*: 1 Point per Credit
	SS4.1—*Alternative Transport—Public Transportation Access*: 6 Points per Credit
	SS4.2—*Alternative Transport—Bicycle Storage and Changing Rooms*: 1 Point per Credit
	SS4.3—*Alternative Transport—Low-emitting + Fuel-efficient Vehicles*: 3 Points per Credit
	SS4.4——: 2 Points per Credit
	SS5.1—*Site Development—Protect or Restore Habitat*: 1 Point per Credit
	SS5.2—*Site Development —Maximise Open Space:* 1 Point per Credit
	SS6.1—*Stormwater Design—Quantity Control*: 1 Point per Credit
	SS6.2—*Stormwater Design—Quality Control*: 1 Point per Credit
	SS7.1—*Heat Island Effect—Non-roof*: 1 Point per Credit
	SS7.2—*Heat Island Effect—Roof*: 1 Point per Credit
	SS8—*Light Pollution Reduction*: 1 Point per Credit
Water efficiency Weighting 9.1 % Maximum points 10.0	WEP1—*Water Use Reduction*: Aims for water use reduction in irrigation. 1 Point per Credit
	WE1—*Water Efficient Landscaping*: 4 Points per Credit
	WE2—*Innovative Waste Water Technologies*: 2 Points per Credit
	WE3—*Water Use Reduction*: 4 Points per Credit
Energy & atmosphere Weighting 31.9 % Maximum points 35.0	EAP1—*Fundamental Commissioning of Building Energy Systems*: 1 Point per Credit
	EAP2—*Minimum Energy Performance*: Requires the building to be designed to ASHRAE 90.1 without the need to specifically require technologies or design solutions. 1 Point per Credit
	EAP3—*Fundamental Refrigerant Managemen*t: Relates to refrigeration. 1 Point per Credit
	EA1—Optimise Energy Performance: 19 Points per Credit
	EA2—*On-site Renewable Energy*: 7 Points per Credit
	EA3—*Enhanced Commissioning*: 2 Points per Credit
	EA4—*Enhanced Refrigerant Management*: 2 Points per Credit
	EA5—*Measurement and Verification*: 3 Points per Credit
	EA6—*Green Power*: 2 Points per Credit

(continued)

Table 4.15 (continued)

Environmental Category Total Weighting = 100 % Max. pts. 110	Credit Descriptions
Materials & resources Weighting 12.7 % Maximum points 14.0	MRP1—Storage and Collection of Recyclables: Aims for appropriate storage for recyclable waste with a focus on rewarding recycling rather than merely reducing waste in the first place. 1 Point per Credit
	MR1.1—*Building Re-use—Maintain Existing Walls, Floors and Roof*: 3 Point per Credit
	MR1.2—*Building Re-use—Maintain Existing Interior Non-structural Elements*: 1 Point per Credit
	MR2—*Construction Waste Management*: 2 Points per Credit
	MR3—*Material Re-Use*: 2 Points per Credit
	MR4—*Recycled Content*: 2 Points per Credit
	MR5—*Regional Materials*: 2 Points per Credit
	MR6—*Rapidly Renewable Materials*: 1 Point per Credit
	MR7—*Certified Wood*: 1 Point per Credit
Indoor environmental quality Weighting 13.6 % Maximum points 15.0	IEQP1—*Minimum Indoor Air Quality Performance*: 1 Point per Credit
	IEQP2—*Environmental Tobacco Smoke (ETS) Control*: 1 Point per Credit
	IEQ1—*Outdoor Air Delivery Monitoring*: 1 Point per Credit
	IEQ2—*Increased Ventilation*: 1 Point per Credit
	IEQ3.1—*Construction Indoor Air Quality Management Plan*—During Construction: 1 Point per Credit.
	IEQ3.2—*Construction Indoor Air Quality Management Plan*—Before Construction: 1 Point per Credit
	IEQ4.1—*Low-emitting Materials—Adhesives and Sealants*: 1 Point per Credit
	IEQ4.2—*Low-emitting Materials—Paints and Coatings*: 1 Point per Credit
	IEQ4.3—*Low-emitting Materials—Flooring Systems*: 1 Point per Credit
	IEQ4.4—*Low-emitting Materials—Composite Wood and Agrifibre Products*: 1 Point per Credit
	IEQ5—*Indoor Chemical and Pollutant Source Control*: 1 Point per Credit
	IEQ6.1—*Controllability of Systems—Lighting*: 1 Point per Credit
	IEQ6.2—*Controllability of Systems—Thermal Comfort*: 1 Point per Credit
	IEQ7.1—*Thermal Comfort—Design*: 1 Point per Credit
	IEQ7.2—*Thermal Comfort—Verification*: 1 Point per Credit
	IEQ8.1—*Daylight and Views—Daylight*: 1 Point per Credit
	IEQ8.2—*Daylight and Views—Views*: 1 Point per Credit
Innovation in design Weighting 5.5 % Maximum points 6.0	ID1—*Innovation in Design*: 5 Points per Credit
	ID2—*LEED Accredited Professional (AP)*: 1 Point per Credit
Regional priority Weighting 3.6 % Maximum points 4.0	RP—*Regional Priority*: 4 Points per Credit

Case Studies from China, Australasia and Singapore

First People's Hospital of Shunde, Foshan District, Guangdong, China

Funded by the Chinese government, the massive new public hospital is located on the outskirts of the Shunde district of Foshan, a city of 5.4 million that is planned to merge with Guangzhou, capital of Guangdong province another city of more than 10 million to create a metropolitan area of GuangFo. Situated in the outskirts of the historical city, it is envisaged that the hospital provide an impetus for growth and regeneration of the local community.

The Shunde Hospital Project represents the outcome of an international competition to design a hospital project with an estimated 1,110.50 million CNY ($175.6 million) budget won by HMC Architects (Ontario, California-based practice) with China's Foshan Shunde Architectural Design Institute (as a partner handling the construction documentation). Initial plans for 1,500 beds and 2.2 million square feet were later changed to a bed count of 2,300 and an area of some 2.8 million square feet (260,128.5 m^2).

Due for completion in 2012, the new hospital replaces an ageing, overcrowded 800-bed facility in the old part of the district. During design, local climate, city planning and infrastructure were analysed to create a sustainable architecture that is tailored to meet the medical needs of a rapidly growing community (Figs. 4.59, 4.60, 4.61 and 4.62).

The design incorporates modern technology while conforming to the customs and needs of the local population. First People's Hospital of Shunde offers a concept that celebrates the longstanding traditions of Eastern medicine, culture,

Fig. 4.59 First People's Hospital of Shunde, Foshan District—Aerial view (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.60 First People's Hospital of Shunde, Foshan District—Main entrance (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

and design, as well as the innovative Western approach to healthcare design that minimises hospital errors, maximises productivity, promotes efficiency, and incorporates sustainable design choices. The plan represents the next step in the evolution of healthcare delivery.

1. *Communication, Arrival on the Hospital Site and Segregation of Flows*: The hospital layout reflects the reality, in China, where people do not routinely communicate with physicians or hospitals prior to showing up but arrive on foot, by bicycle, by bus and in their thousands each day first thing in the morning and after lunch. For this purpose, the centrepiece of the hospital is, therefore, a giant atrium designed to accommodate as many as 4,000 people queued up to see a doctor. Also intended to aid navigation and ease the flow of visitors through the campus is the most striking feature of the hospital, a wood-coloured wall along a walkway that winds through the buildings. The clarity of the diagram is meant to help the visitors easily find their way including the many who will be illiterate. The easily recognisable wall is made with terra cotta, a traditional product of Shunde, which produced cookware long before the arrival of electronics and appliance factories (Figs. 4.61, 4.62, 4.63).
2. *Master Planning, Spatial Layout and Building Organisation*: The design combines a series of organised buildings linked by a dynamic, curved spine element, which creates a grand interior promenade and 'eco-atrium', connecting and harmonising the elements of the hospital. A landmark structure or tower intersects the spine and marks the location of the main plaza and serves as the symbolic heart of the campus.

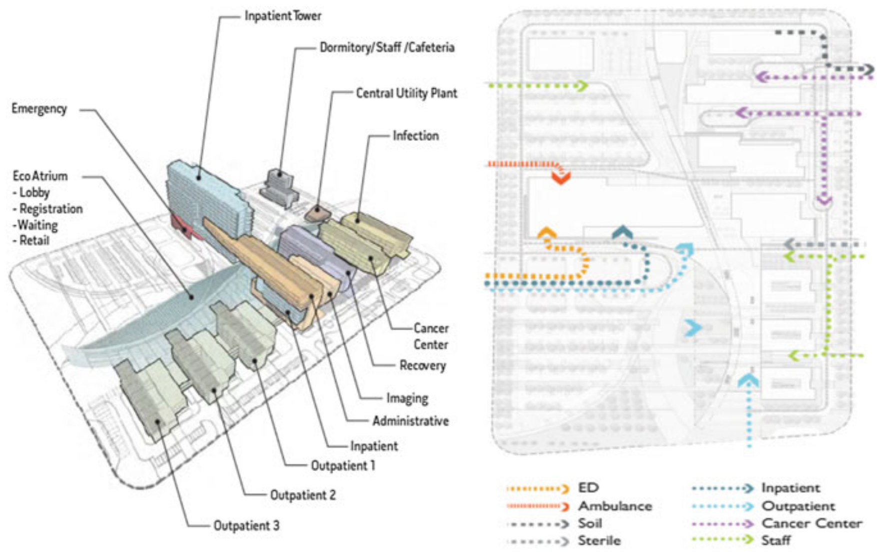


Fig. 4.61 First People's Hospital of Shunde, Foshan District—Site layout (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

The curving spine structure and main tower work together to organise the site into four distinct quadrants: public access, outpatient services unit, support space, and a quiet zone. The separation of these functions serves to resolve any potential conflicts, improve privacy and operational efficiency, reduce anxieties and enhance navigation and wayfinding (Ottosson and Grahn 2005; Grahn and Stigsdotter 2003; Passini et al. 2000; Tennessen and Cimprich 1995; Cimprich 1993). At the point where the spine passes through the main tower building, an iconic red opening creates a symbolic heart for the campus (Figs. 4.64, 4.65 and 4.66, Table 4.16).

Campus organisation is divided into four major zones: outpatient, inpatient, cancer centre and administration/support. All buildings are organised around the dynamic spine and the 'Eco-Atrium'. This naturally ventilated space houses the lobby, registration, waiting, retail areas and circulation to connect all major components of the hospital.

The organisational strategy allows the buildings to be connected for the ease of operational support yet separated for epidemic control. The campus' sustainable design strategy aims to optimise building performance as well as to sustain the mission of this outreaching facility. The open campus planning maximises patient access to privacy, nature, and green spaces—all key attributes to healing (Figs. 4.67 and 4.68).

3. *Day Light and Natural Ventilation*: Building orientation and massing maximises day-lighting and natural ventilation to provide comfortable conditions

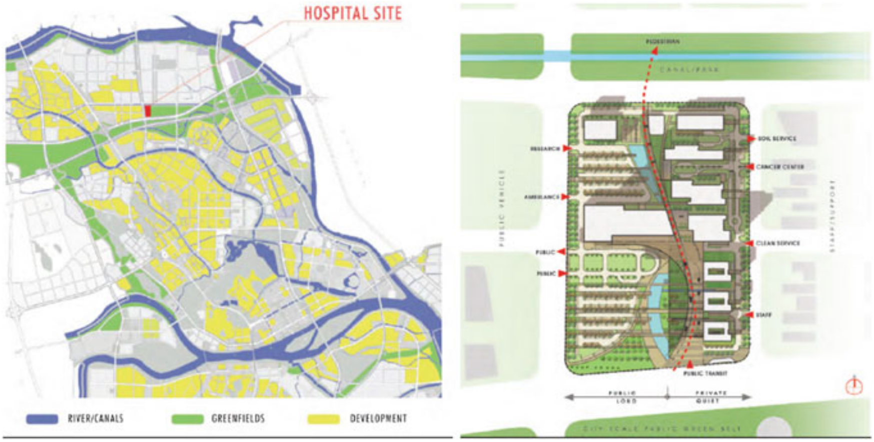


Fig. 4.62 First People's Hospital of Shunde, Foshan District—Location of hospital + site layout (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.63 First People's Hospital of Shunde, Foshan District—Arrival to the hospital site (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

that reduce solar heat gain and glare while capturing renewable energy. Abundant natural light in the interior spaces also serves to support a healing environment with improved healthcare outcomes (Beauchemin and Hays 1996; Ulrich 1984) while reducing energy consumption and meeting targets for sustainability (Figs. 4.69, 4.70, 4.76)

4. *Access to Nature and Healing Gardens*: By incorporating indoor and outdoor green spaces and 'healing gardens', the Shunde Hospital campus honours both Eastern and Western traditions and ideas regarding incorporating therapeutic properties of nature in the built healthcare environment and provision of well-designed landscaped places for patient healing, family gathering, relaxation and privacy (Nordh et al. 2009; Van den Berg et al. 2007; Sherman et al. 2005; Varni et al. 2004; Taylor et al. 2001, 2002; Kaplan and Kaplan 1989). Local materials and locally sourced products used to construct the facility aim to help

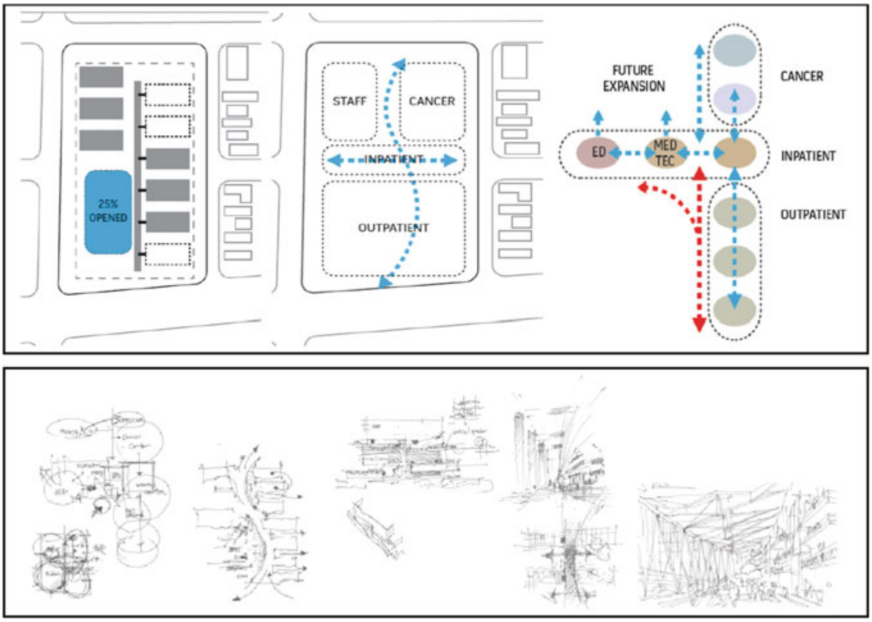


Fig. 4.64 First People's Hospital of Shunde, Foshan District—Master Planning—Circulation Analysis: Sketches by Raymon Plan, Senior Vice President/Design Principal HMC Architects Los Angeles 2009 (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

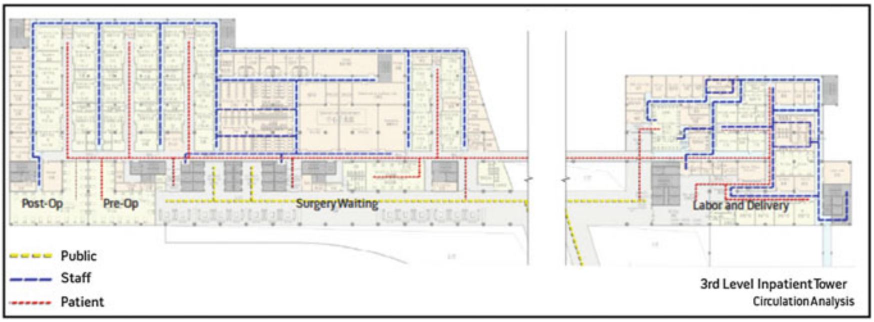


Fig. 4.65 First People's Hospital of Shunde, Foshan District—Traffic flows + Circulation Analysis (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

stimulate the local economy and by so doing also add to sustainable features, which include recycled water features for cooling. The water features also serve to mask ambient noise, provide visual comfort and distraction for patients, staff and visitors.

Fig. 4.66 First People's Hospital of Shunde, Foshan District—Hospital view (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

5. *Semi-private, Private and 'VIP' Private Inpatient Rooms*: At 2,400,000 ft^2 (222,967.3 m^2) in gross floor area, the Shunde hospital Project aims to be a major regional medical centre with a complex programme consisting of an Inpatient Tower for approximately 2,000 beds, acute care Facility, outpatient services unit, Chinese medicine centre, cancer centre, medical research laboratories, infectious disease facility, 2,000 parking spaces, and a staff dormitory. Although huge by U.S. standards (where an over 1,000-bed hospital is considered unmanageable), the Shunde Hospital Project accommodates over 2,000 beds a figure for the size of the new hospital which is about average for a public hospital in a major Chinese city.
   Most of the beds are in semi-private (two-bedded) rooms contrary to the trend in the West backed up by studies that advocate the provision of single bedded rooms because shared rooms lead to higher infection rates (Crimi et al. 2006; Jiang et al. 2003; Hahn et al. 2002; Ben-Abraham et al. 2002; McManus et al. 1992) and exacerbate pandemic outbreaks, result in more medical errors, violations of privacy and confidentiality issues, noisy conditions (Donahue 2009; Trites et al. 1970), reduce bed management flexibility, efficiency and effectiveness (Phiri 2004; Lawson and Phiri 2003) including making sure that male and female patients have roommates of the same sex and produce harmful stress which impedes the healing process. Patients in private rooms are less susceptible to disease transmission or exposed to airborne infections that waft over from a roommate, are less likely to fall and to get the wrong medication or

Table 4.16 First People's Hospital of Shunde, Foshan District—Factsheet

First People's Hospital of Shunde, Foshan District China—Factsheet
Project type: Hospital (Polyclinic). 1,500 beds (6,000 outpatients/day)
Project components: Inpatient: General Surgery, General Medicine, Intensive Care Unit, Paediatrics, Gynaecology, Obstetrical Department, E.N.T. (Ear-Nose-Throat Department), Ophthalmology, Department of Infectious Diseases, and Cancer Care Centre
Outpatient: General Medicine Department, General Surgery Department, Paediatrics, Gynaecology, Obstetrical Department, Dermatology, Stormatology, E.N.T. (Ear-Nose-Throat Department), Ophthalmology, & Pain Management
Medical laboratory: Operation Department, X-ray Department/Department of Radiology, Department of Clinical Laboratories, Function Test Zone, Dialysis Centre, Rehabilitation Centre, Endoscopy Centre, Department of Hyperbaric Oxygen (HBO), Nuclear Medicine Centre, Pathology Department, and Reproductive Medicine Centre
Emergency: Designed based on the concept of Emergency Centre, including Accident & Emergency Consultation, Emergency (Rescue) Room, Emergency Operation Room, Radiology Laboratory, Emergency Laboratory, Function Assessment and Diagnostics
Type of construction: New Construction
Size: 260,128.5 m^2 (2.8million SF) 215,000 m^2 (2.2million SF) 2,000 BEDS, 6000OUTPATIENT VISITS/DAY, 500 EMERGENCY DEPARTMENT VISITS/ DAY 2,000 PARKING SPACES (900 SURFACE AND 1,100 STRUCTURE)
Cost: Total Cost—1,800,000,000CNY (including the land-acquisition fees), Cost per m^2–6,900CNY/m^2
Procurement: Traditional route (though based on an international open bid as start)
Professional services: Architecture, Landscape Architecture, Civil Engineering, Electrical Engineering, Master Planning, Geotechnical Engineering, Cost Consulting, and Project Management
Project team: Client—the FoShan Shunde Construction Project Centre + the Shunde First People's Hospital, Architect—Shunde Architectural Design Institute + HMC Architects, Construction Manager—ZheJiang ZhongYuan Construction Design (Group) Co.
Other collaborations:—GuangDong HongYuan Construction Project Consulting Ltd.
Evidence-Based architectural design features and interventions: Improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family, and staff satisfaction, accommodating Chinese practices and local traditions, and provide ability & capacity to adapt to the future
Sustainable design features: Daylighting, Landscaping Views, Water Landscape and Features with recycled water for cooling (Evaporative cooling effects from the lake will help to draw in cool air during the day time and moderate the night time temperature fluctuations), Energy Efficiency, and 1,500 Mwh of solar generated electricity from 15,000 m 2 Building-Integrated Photovoltaic (PVs) Arrays (use of renewable technologies), and Intelligent HVAC (Heating Ventilation Air Conditioning) System. The design ensures that transport hierarchy issues are fully addressed and catered for
AutoCAD EcoTECT software was used for simulation and modelling studies, crucial in identifying the **Four Wall Systems**: **1**.Window wall system with balconies provides views of garden and minimises solar and heat exposure to rooms facing south. **2**. Glass curtain wall system with sun shading screens maximises visual connection while filtering sunlight in, reducing solar exposure. **3**. Low emission insulating glass curtain wall system used predominantly on the north façade. This maximises indirect sunlight and views to the outdoors. **4**. Low emission glass curtain wall system with light shelves provides controlled shading while deflecting natural light deep into the room. Overall, sustainability features aim to respond to the hospital's location in the Guangdong province, which belongs to the hot summer and warm winter zone, one of the 5 climate zones in China

Fig. 4.67 First People's Hospital of Shunde, Foshan District—The 'Eco-Atrium': the design of the hospital integrates the medicine and culture of the East with the innovation of the West under one attractive and functional roof (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.68 First People's Hospital of Shunde, Foshan District—'Eco-Atrium' 2, a naturally ventilated space that houses the lobby, registration, waiting, retail areas and circulation to connect all major components of the hospital (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

experience other medical errors because they were confused with a roommate; sleep better and maintain better spirits when there is not another patient in the room snoring, coughing or crying in pain in a nearby bed and they see only their own relatives and visitors. Furthermore, patients in private rooms with en

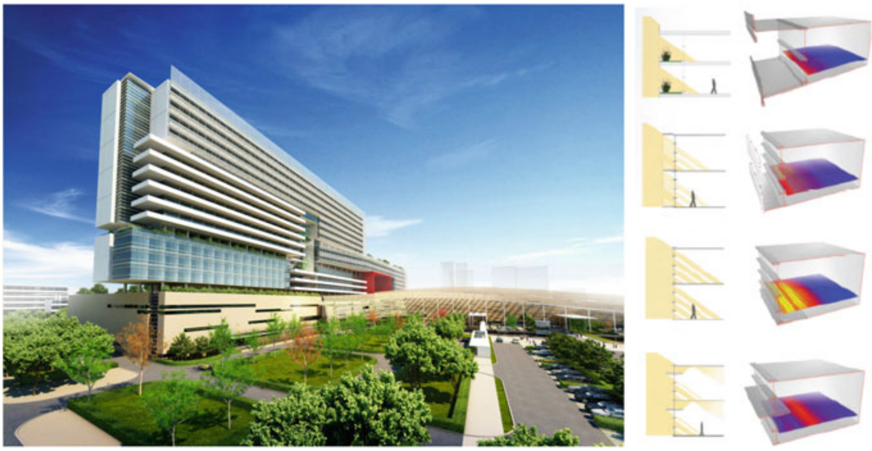


Fig. 4.69 First People's Hospital of Shunde, Foshan District—Four external wall systems: 1. Window wall system with balconies provides viewing garden and minimises solar and heat exposure to rooms facing south. 2. Glass curtain wall system with sun shading screens maximises visual connection while filtering sunlight in, reducing solar exposure. 3. Low emission insulating glass curtain wall system used predominantly on the north façade. This maximises indirect sunlight and views to the outdoors. 4. Low-emission glass curtain wall system with light shelves provides controlled shading while deflecting natural light deep into the room (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

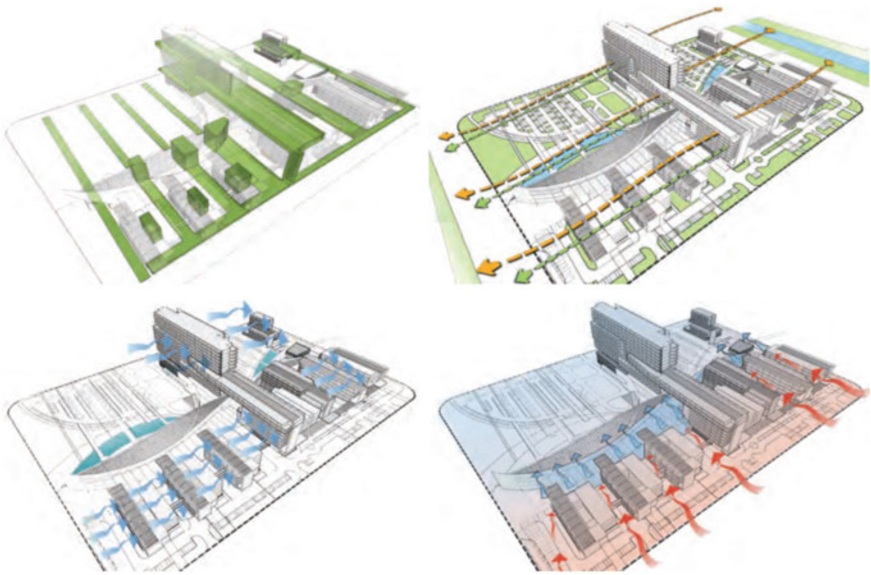


Fig. 4.70 First People's Hospital of Shunde, Foshan District—Natural ventilation strategy (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.71 First People's Hospital of Shunde, Foshan District—Inpatient room layouts (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

suite do not share a bathroom where bacteria lurk including not being touched by staff without washing hands between contacts or after touching or handling privacy curtains, blood-pressure cuffs, computer keyboards and other equipment used for patients in a shared in room (Figs. 4.71, 4.72, 4.73, 4.74 and 4.75).

Fig. 4.72 First People's Hospital of Shunde, Foshan District—2-Person 3D typical inpatient room (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

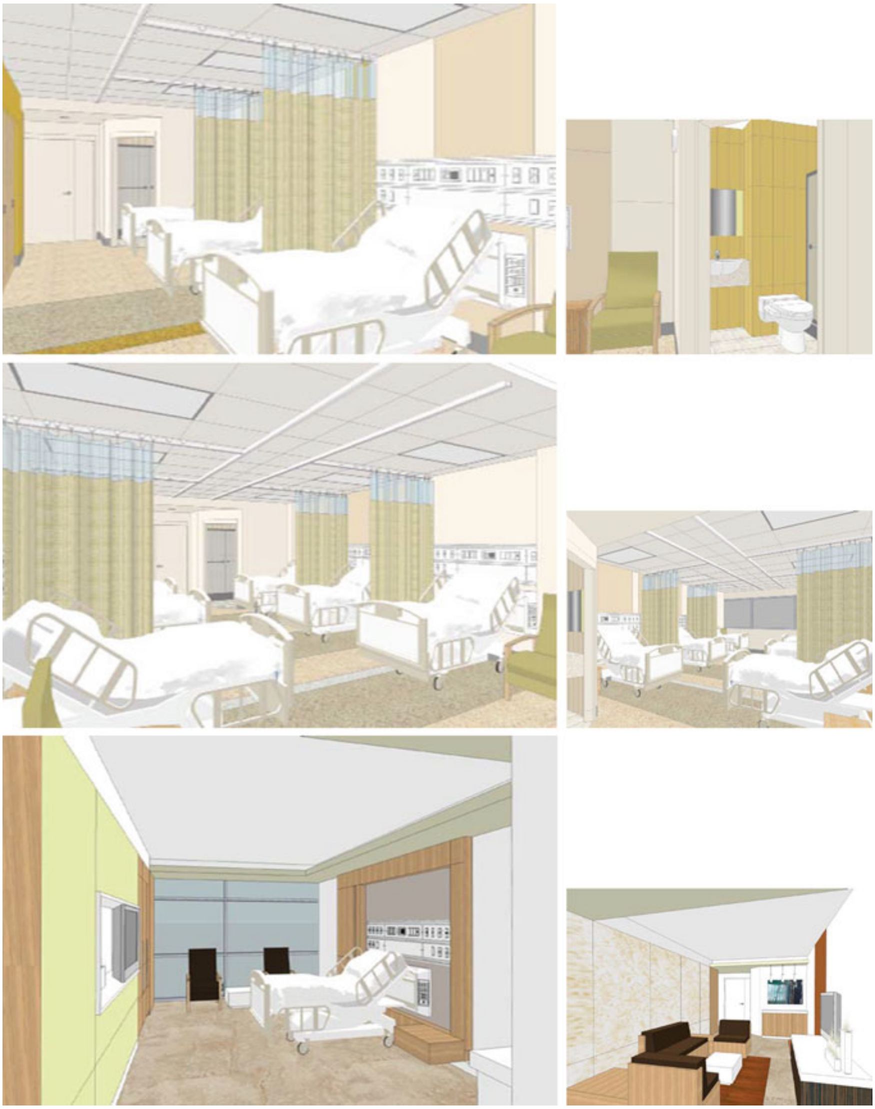


Fig. 4.73 First People's Hospital of Shunde, Foshan District—3-Person, 6-Person and VIP 3D typical inpatient rooms (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

6. *Increasing patient, family and staff satisfaction*: Though still out of reach for some, patients at the Chinese public hospitals pay a nominal fee for basic services, and the hospital charges extra for private rooms regarded as one of the pecks. The Shunde hospital also has 300 'VIP' private rooms generously sized

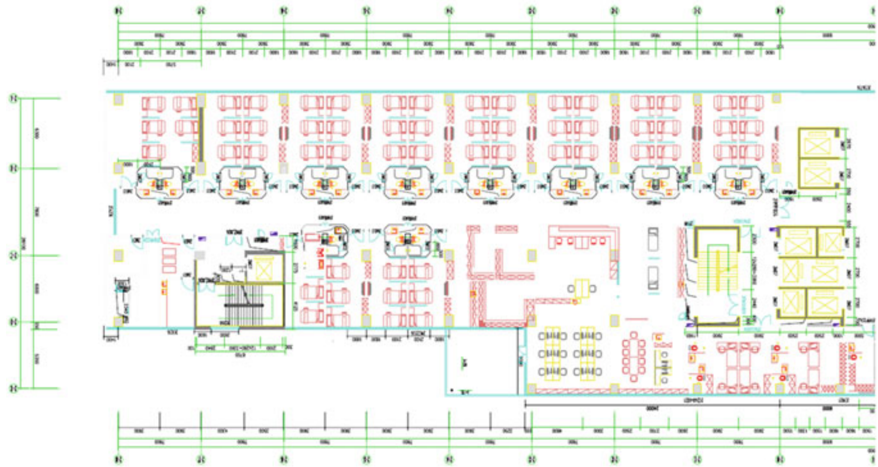


Fig. 4.74 First People's Hospital of Shunde, Foshan District—Ward layout (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012). 'The inpatient beds should be laid in parallel with the windows. Normally, no more than 3 beds if it is a single row (no more than 4 beds if there is a special situation); no more than 6 beds if they are arranged in two rows (no more than 8 beds if there is a special situation). The distance between two beds in parallel should no less than 0.80 m; the distance between the far-end bed and the wall should no less than 0.60 m. If the beds are arranged in a single row, the width of the aisle should no less than 1.10 m; if the beds are arranged in two rows, the width of the aisle between two rows should no less than 1.40 m. The distance between the nurse station and the inpatient rooms (door) should no more than 30 m'. (Ministry of Construction and Ministry of Health PR China 1988: 25)

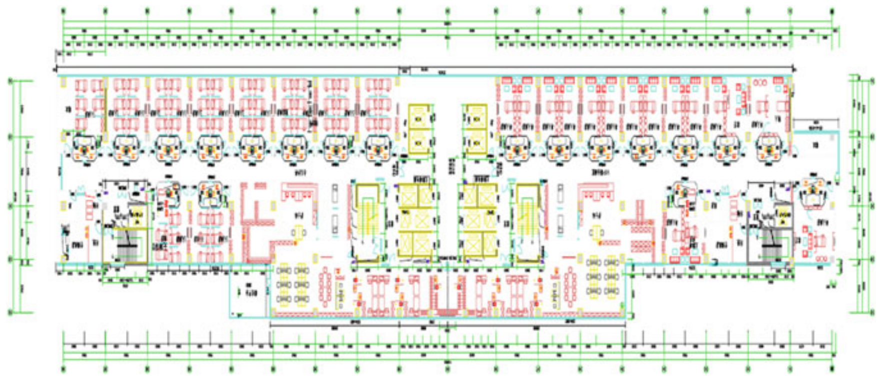


Fig. 4.75 First People's Hospital of Shunde, Foshan District—Ward layout 2 (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

with adequate space for family members. Public hospitals rely on charging affluent patients for perks in order to cover costs and improve patient satisfaction. Opinion surveys in the United States found that patient satisfaction scores went up sharply after a hospital switched to all-private rooms, because the 500-bed hospital was then able to provide equal accommodations for both affluent and less-well-off patients.

7. *Design for Sustainability*: Responding to the government's request that the hospital serve as a model of sustainable hospital construction the atrium is designed as an 'eco-atrium' covered with photovoltaic sunscreens, generating some 330 megawatt hours per year. Sustainability design features aim to respond to the hospital's location in the Guangdong province, which belongs to the hot summer and warm winter zone, one of the 5 climate zones in China (Figs. 4.76, 4.77, 4.78, 4.79, 4.80, 4.81 and 4.83, Tables 4.17 and 4.18).

The terra cotta wall is configured to block the western sunlight, keeping the atrium cool during the hot summer afternoons and warming the space at night by emitting the heat absorbed during the day.

The hospital campus aims to be a vital component of the new master planned urban community in which it resides, tying directly into the urban transportation system for patient access. Additional sustainable design features include photovoltaic panels on the roof, chilled beams in the eco-atrium, and non-toxic paints throughout the hospital to limit indoor air contaminants.

The hospital is designed to be a hub for renewable solar energy as all south-facing façades and building roof shading structure are provided with photovoltaic panels to generate electricity that supplements more than 1,500 Mwh of the hospital's energy use annually. Thermal mass, solar screens and geothermal energy

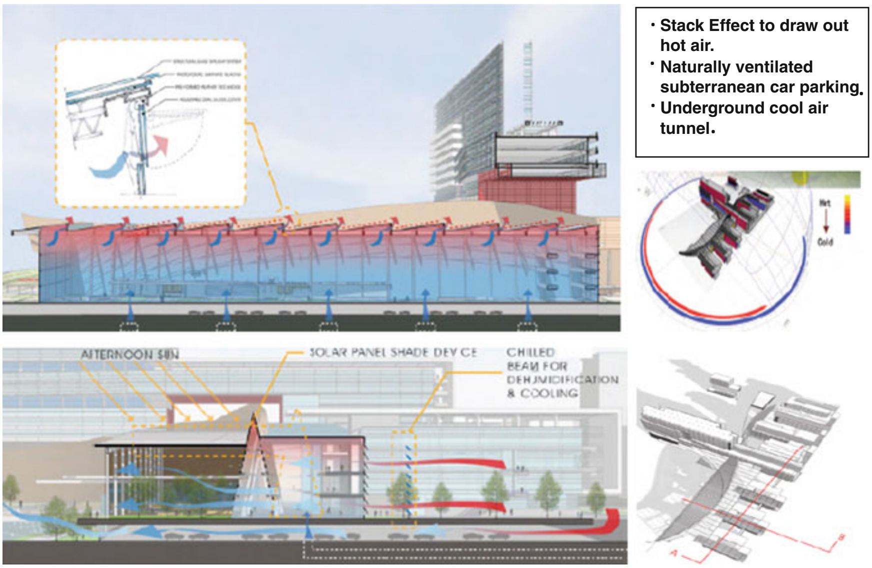


Fig. 4.76 First People's Hospital of Shunde, Foshan District—Natural ventilation strategy 2 (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

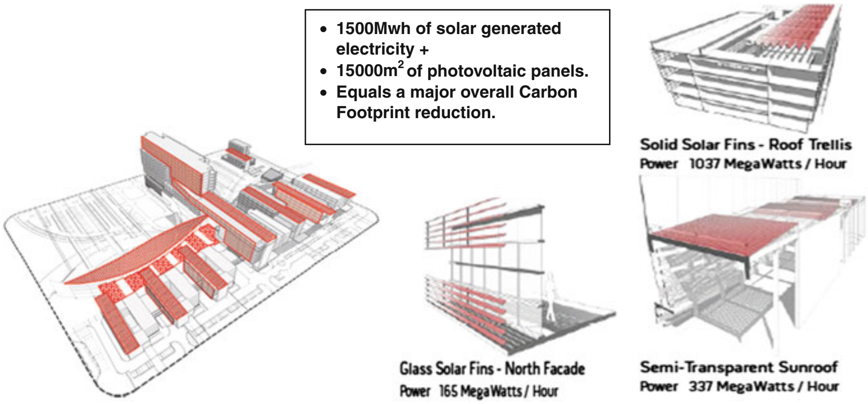


Fig. 4.77 First People's Hospital of Shunde, Foshan District—Design for sustainability (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.78 First People's Hospital of Shunde, Foshan District—Model of hospital site at night (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

(underground air tunnels) are used as passive means in regulating indoor temperature. The efficient site planning allows for abundant open space to anticipate future expansion.

Finally, its iconic architecture engages the local heritage and building industry/material. In so doing, the design and planning of the First People's Hospital seeks

Fig. 4.79 First People's Hospital of Shunde, Foshan District—View of the bedroom tower (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

Fig. 4.80 First People's Hospital of Shunde, Foshan District—View of the tower 2 (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012)

to respond to the practice, place and culture of Shunde District. The use of terracotta as the campus main building exterior material continues and reinforces the City of Shunde's manufacturing tradition as the 'Terracotta City' in China. Also

Fig. 4.81 First People's Hospital of Shunde, Foshan District—Water as a design feature (*Source* HMC Architects + Foshan Shunde Architectural Design Institute 2012). Studies of water perception (summarised in Coss 2003) show that people respond very positively to sparkle, reflections, and surface movements of water

known as the 'Water City', the network of water elements on campus is evocative of the city's famed canals, which are integrally intertwined with the local residents' lifestyles (Fig. 4.81).

8. *Evidence-Based Design integrated with Local Chinese Traditions and Practices*: The fusing, acknowledging and respecting of the traditional medical practices in China while knowledge gained in studies conducted in the West identifying and implementing interventions of improving on functionality, minimising errors, maximising productivity and incorporating sustainability to deliver healthcare services for up to 1,500 resident patients and 6,000 outpatients a day are the essentials of integrating design for sustainability and evidence-based design principles (Figs. 4.82, 4.83, Tables 4.19, 4.20).

Focus groups were also used to elicit opinions of potential users to inform the designs of the Shunde Hospital Project.

Table 4.17 First People's Hospital of Shunde—Green Hospital Building evaluation criteria

		Credits	Description of potential credits to achieve ★★ 2–★★★3 star rating
A. General items (35)	1. Planning (6)	6 items in total	4.0.09 *The building shape coefficient is designed to meet the national standards for energy efficiency of public buildings*
			4.0.10 *The onsite acoustic environments are designed to meet the current national standards* such as the Environmental Quality Standards for Noise GB3096. Residential buildings such as inpatient buildings, staff accommodation, etc. should not be located near the roads; otherwise technical measures need to be done to improve the capability of sound insulation
			4.0.11 *The wind speed in the pedestrian areas around the buildings* should be less than 5 m/s and should not have negative impacts on outdoor activities or indoor natural ventilation. For hospitals located in the Cold and Severe Cold Zones, the main entrance should be designed with wind proof facilities for temporary parking; for hospitals located in the Hot-Summer and Warm-Winter or Hot-Summer and Cold-Winter zones, the main entrance should be designed with shading facilities for temporary parking
			4.0.12 A*void having large area of hard pavement around the buildings*. For flat roofs that have not been occupied by equipments, more than 50 % of them should be covered by green plants or high reflectivity materials; for pitched roofs, they should be covered with high reflectivity materials or be designed with ventilation systems underneath
			4.0.13 *Use local green plants that could grow well in the given conditions* such as local climate and soil. Should mix arbour, frutex and grass in terms of green space designs
			4.0.14 *The location of the hospital should be logically decided* in order to reduce the transport needs for staff and patients. The onsite transport should be well organised, for instance having pedestrian roads connect the main building entrances and public transport nodes
	2. Architecture (6)	5 items in total	5.0.11 *Hospital designs should reflect people-oriented principle* by increasing the leisure and waiting spaces. At least, 5 % of the construction site should be designed as leisure space that provides patients, visitors and staff with access to natural environments
			5.0.12 *The internal spaces of hospitals* should be designed with systematic safety measures in order to avoid the unnecessary harm to people
			5.0.13 *Use solid and durable materials for hospital interior designs*. The surface materials for partition walls, doors and columns should be able to resist horizontal forces. The wall surfaces should be covered with durable, washable, disinfectant and antibacterial materials
			5.0.14 P*revent the potential negative impacts of building's non-structure parts on safety* under any circumstance. Avoid any functional failure, harm to people or crowded corridors/halls resulted by natural disaster or other unexpected matters
			5.0.15 Use elastomeric floors in the inpatient rooms and the ward corridors (or other measures) to reduce noise levels

(continued)

Table 4.17 (continued)

	Credits	Description of potential credits to achieve ★★ 2–★★★3 star rating
3. Equipment and Systems (10)	9 items in total	6.0.9 *The energy supply, water supply, gas supply and other energy consumption for buildings should be monitored* and calculated separately according their own purposes and service areas 6.0.10 *Choose building equipments that can run properly* in either full-load or part-load situations and use building monitoring system to monitor and control these equipments in an energy saving manner 6.0.11 Use the electricity-driven air-condition water chillers that can meet at least Level 2 standard under the Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grades for Water Chillers GB19577 and unitary air conditioners that can meet at least Level 3 standard under the Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grades for Unitary Air Conditioners GB19576 6.0.13 *Run the debugging test for HVAC systems* (e.g. wind, water and relevant equipments) to generate a formal test report showing that all HVAC equipments can run in line with design requirements and standards 6.0.14 *The no load or load loss of the 10/0.4 kV transformers* should be less than the allowable values of the energy efficiency as required by relevant national standards. There should be automatic compensating devices and power factor meters being installed in the transformer and distribution substations. The compensating value of power factors should meet the national regulations or requirements addressed by the local power supply departments 6.0.15 *The transformer and distribution substations* should be located close to the power load centre 6.0.16 *Use water-saving facilities to save water*. Water supply systems are designed to accommodate a range of water qualities to ensure the onsite water can be supplied according to the required water quality 6.0.17 *Have effective control systems for artificial lighting* (based on different functional zones and different period of time) under the circumstance of healthcare targets had been successfully achieved 6.0.18 *Use information systems to communicate healthcare data through intranet efficiently*
4. Environment and Environmental Protection (7)	5 items in total	7.1.13 *Use natural ventilation first for rooms* without special requirements for air quality control 7.1.16 *The filters (and necessary purifying facilities) for fresh air should be designed* as required by the Architectural and Design Code for General Hospital JGJ49 7.1.17 *The HVAC systems for clean rooms (e.g. operation rooms) and highly polluted rooms (e.g. infection rooms) should be set independently* to allow these air conditional zones could be closed whenever necessary without influence to other areas 7.2.10 *Noise control for power sources* (including air pressure stations, vacuum pumps, boilers, gas turbines, diesel generators, refrigerators, water pumps, etc.) should meet the current national standards—the Environmental Quality Standards for Noise GB3096 7.2.11 *There are areas in the hospitals being particularly designed to take over, recycle and deposit dangerous* materials such as medical wastes, pathogenic or infectious things, toxic stuff, and radioactive materials

Table 4.17 (continued)

		Credits	Description of potential credits to achieve ★★ 2—★★★3 star rating
5. Operation Management (6)	6 items in total	8.0.8 T*ake measures to reduce energy*	*consumption, save water, reduce pollutions and wastes* in the operational phase of hospitals 8.0.9 *Take measures to encourage green transport such as public transport, bicycles, walking and reduce the use of private cars*. Have convenient and well-designed bicycle racks to enable bikes to be easily stored and accessed 8.0.10 *Measure the energy consumption in the operational phase of hospitals* and then provide rewards or punishments to each department based on the statistic results 8.0.11 I*mprove the resilience capacity of technical systems* including information system, electricity system, communication system, water supply, fuel, healthcare gases, heating system, ventilation system and HVAC, etc. as well as the resilience capacity of healthcare facilities located in some important areas such as ICU, emergency rooms, operation rooms, etc. in natural disasters. Have alternative options for continuing healthcare service under unexpected circumstances such as natural disasters or other emergencies 8.0.12 A*dopt protection measures to safeguard the places that store harmful chemicals*, medicines, radioactive materials, flammable and explosive goods, pressure vessels, toxic or bacteria species 8.0.13 Check the quality of all healthcare gases and inspect the performance of healthcare gas systems/facilities regularly

Table 4.17 (continued)

		Credits	Description of potential credits to achieve ★★ 2—★★★3 star rating
B. Optimal Items (33)	6. Optimal items (33)	16 items in total	5.0.17 *Use ecological measures* (e.g. green roofs, plants for shading, etc.) to reduce buildings' energy requirements 5.0.19 *Use frame structure to allow buildings (e.g. interior spaces) can be easily adapted for future development* 6.0.19 *Use energy saving and water saving measures based on the whole life analysis* 6.0.20 *Use intelligent lighting control system that can adjust the illumination as required*. Such system should be applied to more than 30 % of the total construction areas. Use energy-efficient lighting equipments and other relevant electric facilities 6.0.26 *Use integrated measures that are uncovered by the 'general items' or 'optimal items' but have been proved reliable and financially feasible*. Based on calculation/simulation, by taking these integrated measures, the hospital should be able to reduce more than 3 % of the total energy consumption per year compared to a benchmark hospital 7.1.18 *Improve natural lighting effects for interior spaces and basement spaces.* 7.1.19 *Use outside shading facilities to improve the thermal performance of building facades* as well as the interior thermal comfort 7.1.20 *Using air quality monitoring system to ensure a healthy and comfortable interior environment.* 8.0.14 *Recover the natural environments being damaged during the construction* (i.e. new construction and refurbishment) and operational phases of hospitals 8.0.15 *Take measures to reduce rainwater pollution, light pollution, heat island effect*. Improve the outdoor environments (which can then have a positive impact on the patients' therapeutic outcomes and staff's work efficiency) 8.0.16 *Provide reward schemes for staff using green transport modes* 8.0.17 *Have technical update for facilities or equipments* that have relatively higher energy requirements, water requirements, pollution potentials, etc. 8.0.18 *Choose energy saving, water saving and green goods in daily maintenance and equipment replacement* 8.0.19 *Use monitoring systems to monitor the performance of building equipments* 8.0.21 H*ave plans to accommodate refurbishment or reconstruction activities under the circumstance of natural disaster or emergency*. Refurbishment or reconstruction work can be conducted according to the change of healthcare flows, extension of inpatient beds, infection controls, etc. 8.0.22 *Have evacuation plans for natural disaster or other emergencies and do the rehearsal regularly*. This is to ensure that all patients, staff and visitors can be evacuated to safe places whenever necessary

Source Foshan Shunde Architectural Design Institute & HMC Architects

Table 4.18 Green Hospital Building Evaluation Criteria—Rating benchmarks

GHBEC Rating	General items (35)					Optimal items (33)
	Planning (6)	Architecture (6)	Equipment and systems (10)	Environment and environmental protection (7)	Operation management (6)	
★ Star	2	2	3	2	2	–
★★ Star	3	3	5	4	3	10
★★★ Star	4	4	7	5	4	22

Source Chinese Hospital Association 2012

Fig. 4.82 HMC Architects' principles underlying and underpinning sustainable design of the First People's Hospital of Shunde (*Source* HMC Architects 2012)

Fig. 4.83 Map of People's Republic of China: location of Foshan District, Guangzhou

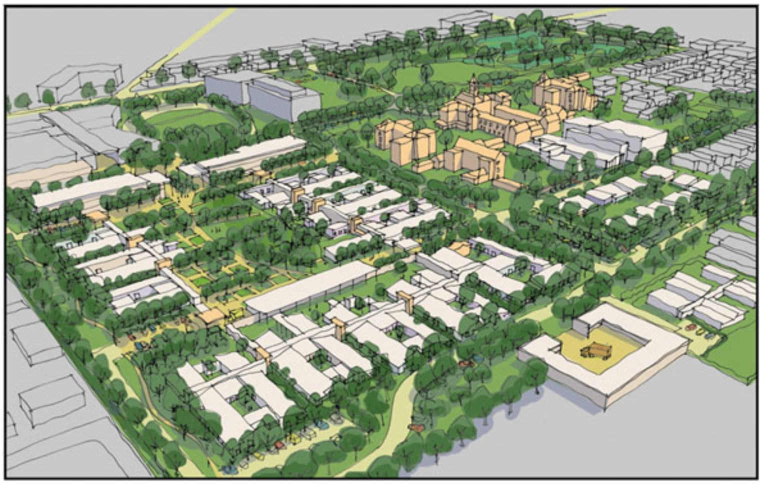


Fig. 4.84 Aerial view of the Glenside campus redevelopment, Australia (*Source* Medical Architecture UK 2012)

Table 4.19 First People's Hospital of Shunde, Foshan District—Aspiration for a LEED Gold Certification

	Mandatory or required prerequisite credits	Potential additional credits
Sustainable sites Weighting 23.6 % Max. points 26.0	SS Prerequisite 1—Construction Activity Pollution Prevention	SS Credit 4.1: Alternative Transportation: Public Transportation Access SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms SS Credit 4.3: Alternative Transportation: Low Emitting + Fuel Efficient Vehicles SS Credit 4.4: Alternative Transportation: Parking Capacity SS Credit 5.2: Site Development: Maximise Open Space SS Credit 6.1: Stormwater Design: Quantity Control SS Credit 6.2: Stormwater Design: Quality ontrol SS Credit 7.1: Heat Island Effect: Non-Roof SS Credit 8: Light Pollution Reduction
Water efficiency Weighting 9.1 % Max. points 10.0	WE Credit 3.1—Water Use Reduction	WE Credit 1.1: Water Efficient Landscaping: Reduce by 50 % WE Credit 2: Innovative Wastewater Technologies WE Credit 3.2: Water Use Reduction: 30 % Reduction
Energy & atmosphere Weighting 31.9 % Maximum points 35.0	EA Prerequisite 1—Fundamental Commissioning of Building Energy Systems EA Prerequisite 2—Minimum Energy Performance EA Prerequisite 3—Fundamental Refrigerant Management	EA Credit 1: Optimise Energy Performance EA Credit 2: On-Site Renewable Energy EA Credit 3: Enhanced Commissioning EA Credit 4: Enhanced Refrigerant Management EA Credit 5: Measurement & Verification EA Credit 6: Green Power
Materials & resources Weighting 12.7 % Max. points 14.0	MR Prerequisite 1—Storage and Collection of Recyclables	MR Credit 2.1: Construction Waste Management: Divert 50 % From Disposal MR Credit 4.1: Recycled Content: 10 % (post-consumer + 1/2 pre-consumer) MR Credit 5.1: Regional Materials: 10 % Extracted, Processed & Manufactured Regionally MR Credit 5.2: Regional Materials: 20 % Extracted, Processed & Manufactured Regionally MR Credit 6: Rapidly Renewable Materials MR Credit 7: Certified Wood

(continued)

Table 4.19 (continued)

	Mandatory or required prerequisite credits	Potential additional credits
Indoor environmental quality Weighting 13.6 % Maximum points 15.0	EQ Prerequisite 1—Minimum Indoor Air Quality (IAQ) Performance	EQ Credit 1: Outdoor Air Delivery Monitoring EQ Credit 2: Increased Ventilation EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants
	EQ Prerequisite 2—Environmental Tobacco Smoke (ETS) Control	EQ credit 4.2: low-emitting materials: paints & coatings EQ credit 4.3: low-emitting materials: carpet systems EQ credit 4.4: low-emitting materials: composite wood & agrifibre products EQ credit 5: indoor chemical & pollutant source control EQ credit 6.2: controllability of systems: thermal comfort EQ Credit 7.1: Thermal Comfort: Design EQ Credit 7.2: Thermal Comfort: Verification EQ Credit 8.1: Daylight & Views: Daylight 75 % of Spaces EQ Credit 8.2: Daylight & Views: Views for 90 % of Spaces
Innovation in design Weighting 5.5 % Max. points 6.0	No prerequisites for this category	ID Credit 1–1.4: Innovation in Design ID Credit 2: LEED accredited professional (AP)
Regional priority Weighting 3.6 % Max. points 4.0	No prerequisites for this category	MR Credit 5.2: Regional Materials: 20 % Extracted, processed & manufactured regionally

Table 4.20 Guangzhou Climate Data (*Source* China Meteorological Data Sharing Service System http://cdc.cma.gov.cn accessed 7 August 2012) Foshan/Guangdong belongs to the Hot-Summer and Warm-Winter zone with an average temperature between 18.9 and 26.3 °C and the relative humidity 77.5 %)

Guangzhou (1971–2000) climate data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All
Average highest temperature °C (°F)	18.3 (64.9)	18.5 (65.3)	21.6 (70.9)	25.7 (78.3)	29.3 (84.7)	31.5 (88.7)	32.8 (91)	32.7 (90.9)	31.5 (88.7)	28.8 (83.8)	24.5 (76.1)	20.6 (69.1)	26.3 (79.3)
Average lowest temperature °C (°F)	10.3 (50.5)	11.7 (53.1)	15.2 (59.4)	19.5 (67.1)	22.7 (72.9)	24.8 (76.6)	25.5 (77.9)	25.4 (77.7)	24.0 (75.2)	20.8 (69.4)	15.9 (60.6)	11.5 (52.7)	18.9 (66)
Rainfall/Precipitation mm (inch)	40.9 (1.61)	69.4 (2.732)	84.7 (3.335)	201.2 (7.921)	283.7 (11.169)	276.2 (10.874)	232.5 (9.154)	227.0 (8.937)	166.2 (6.543)	87.3 (3.437)	35.4 (1.394)	31.6 (1.244)	1736.1 (68.35)
Relative Humidity (%)	72	77	82	84	84	84	82	82	78	72	66	66	77.5
Average Raining Dates	7.5	11.2	15.0	16.3	18.3	18.2	15.9	16.8	12.5	7.1	5.5	4.9	149.2
Daylight hours	118.5	71.6	62.4	65.1	104.0	140.2	202.0	173.5	170.2	181.8	172.7	166.0	1628.0

Lessons from First People's Hospital of Shunde, Foshan District, Guangdong, China

The project is designated as a pilot sustainable hospital in China, allowing exploration of sustainable technologies for future hospitals. The design goal is to translate advanced Western healthcare ideas to accommodate Chinese local practices, creating an innovative healing environment. The fusing and respecting of the traditional medical practices in China and improving on functionality, minimising errors, maximising productivity and incorporating sustainability whilst providing services for up to 1,500 resident patients and 6,000 outpatients a day are the essentials of integrating design for sustainability and evidence-based design principles (Fig. 4.85).

First People's Hospital of Shunde, Foshan District is AIA International award winning Chinese hospital based on evidence-based design principles as well as operational, behavioural and cultural concepts.

Cultural and procedural expectations were factored into evidence-based design drivers for the schematic design for this hospital. Healthcare delivery systems and family involvement require a different interpretation to the 'evidence-based' solutions, which are often applied to hospitals in the United States. An 'inside-out' approach brings the human element into the design with application of brain, body and building science in the architectural or design process. Combined with an 'outside-in' approach, the human element is integrated in planning, programming and design development that also takes account of green sustainable goals.

An important lesson from the First People's Hospital of Shunde Project is that it highlights the issue of national versus international standards, guidance and tools, for example China's Green Hospital Building Evaluation Criteria versus US's LEED Healthcare or UK's BREEAM Healthcare or Australia's Greenstar. The challenge for the project is that of importing these guidance and tools while at the same time there may be problems if the infrastructure (such as monitoring and inspections for compliance) is not in place to enforce them especially if they are breached or not adhered to. The major advantage for any individual country developing its own ensemble of guidance and tools is that they can relate to that country's legislation, healthcare policies and peculiar circumstances. It avoids external dependence of making sure they are up dated according to changes in legislation, regulations and generally healthcare policies. However, it has already been highlighted that a decision for a country to develop and maintain its own guidance system and tools can be costly and requires continual investment in the development of a relevant intellectual base or expertise.

Glenside Campus Redevelopment, Adelaide, Australia

The new AUD$130million 129-bed Glenside Campus Redevelopment, Australia, brings together into one place specialist services for mental health, acute care, rehabilitation, drug and alcohol withdrawal, and perinatal inpatient units alongside outpatient, front-of-house and office and support activities. The strategic and policy context of significant service reform across all sectors of health and mental health is summarised within the South Australia Specialist Health Services Integrated Model of Care (V11, 2008). The Glenside Campus Redevelopment is consistent with the recommendations provided by the Social Inclusion Board in its February 2007 report 'Stepping Up: A Social Inclusion Action Plan for Mental Health Reform 2007–2012'.

The large multi-disciplinary professional team for the new Glenside Healthcare Services Project includes healthcare specialist Architects from the UK Medical Architecture partnering local architects Swanbury Penglase Architects, Adelaide. Widespread consultation with users and stakeholders using a series of interactive workshops was adopted as a critical mechanism to ensure that the completed healthcare facility was of the highest environmental design quality, and would meet requirements of and respond to the specific changing needs of clients or consumers from the South Australian country regions and the Eastern Metropolitan Adelaide region (Table 4.21).

The Glenside Project not only embraces the challenges of physical planning and designing within an urban context but also proposes initiatives for the development of the whole campus in terms of appropriate provision of sitewide multi-functional and flexible integrated infrastructure. The 'Enablement Process' for the project was completed in early 2010 and included upgrading and reconfiguring accommodation for consumers/clients, providing immediate environmental improvements as well

Fig. 4.85 Glenside Campus Redevelopment Australia—'Village-like' configuration around a shared garden: The gardens are designed to indicate a hierarchical progression from public, semi-public, semi-private to private gardens (*Source* Swanbury Penglase Architects 2012)

as trialling and testing new models of care prior to implementation within the entire new healthcare facility (Figs. 4.84, 4.85, 4.86, 4.87 and 4.88).

The modern healthcare facility provides specialist services for mental health, drug and/or alcohol health and social care within the context of both demystifying and de-stigmatising an existing Victorian Asylum dating back to 1836. The design solution combining new build, reconfiguration and modernisation of existing accommodation aims to create a place of refuge, safety, security and healing which derives from an approach that emphasises integration of evidence-based architectural healthcare design and sustainability and whose underlying concept and aspiration is community integration and consolidation as well as being suitable inpatient facilities that are flexible for future models of care (Tables 4.22, 4.23).

1. *Needs Assessment, Option Appraisal for Site Configurations or Spatial Layout and Alignment with Care Model(s)*: Building for highly complex purposes in rapidly changing demographics, clinical, economic and social environment requires those settings to be flexible and to continue to be useful for decades into the future.

   As a basis for deciding on the preferred option Glenside Redevelopment examined, through an analysis of benefits and disadvantages, five options for site reconfigurations.

   Option 1:—Campus Option defined or characterised by permeable buildings as islands in which every one of the residents or users has a front door, fragmented green space, communal space and large buildings.

   Option 2:—Complex Option comprises large central impermeable buildings, single-controlled entrance resulting in visible physical separation from the rest of the community.

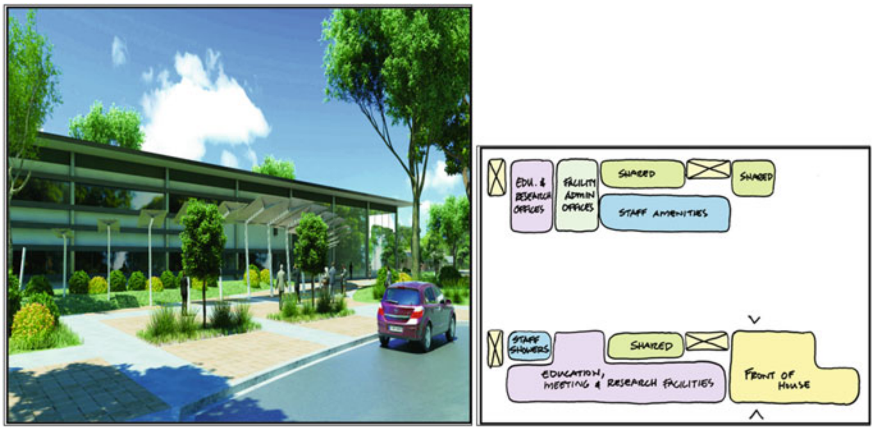


Fig. 4.86 Glenside Campus Redevelopment Australia—'Front of the house' + First point of arrival on the campus (*Source* Medical Architecture UK + Swanbury Penglase 2012)

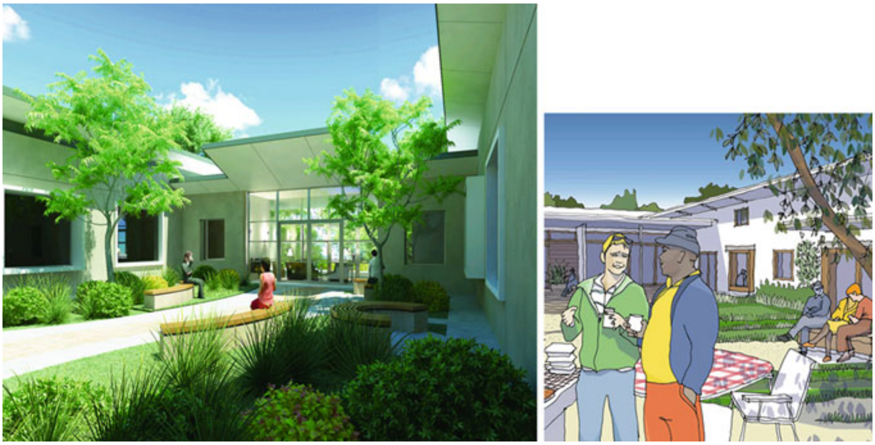


Fig. 4.87 Glenside Campus Redevelopment Australia—Courtyard for 'Park-Bench Therapies': provision of external areas for socialisation, sanctuary and enhancing connection with nature and easy/convenient access to it (*Source* Swanbury Penglase Architects 2012)

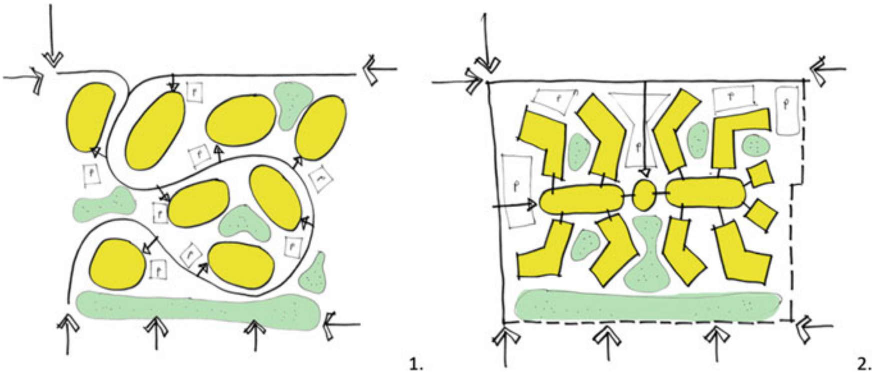


Fig. 4.88 Glenside Campus Redevelopment Australia—Options for Site Configurations: *1* Campus option—Permeable buildings as islands in which every one of the residents or users has a front door, fragmented green space, communal space and large buildings, *2* Complex option—Large central impermeable buildings, single controlled entrance resulting in visible physical separation from the rest of the community (*Source* Swanbury Penglase Architects 2012)

Option 3:—Urban Option characterised by a grid and an extension of the suburb street scene, integration into the community but having own individual address, yet high-density and city park.
Option 4:—Villa Option in which a series of similar sized buildings is arranged around private gardens (typically defined by the 'Almshouse Model' in which buildings comprising small houses or 'villas' provide accommodation for small numbers of residents and often integrated with health and social care resources).

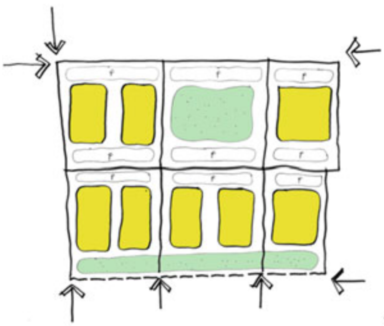
Table 4.21 Glenside Campus Redevelopment, Australia—Factsheet

Glenside campus re-development, Adelaide Australia Factsheet
Building description: Accommodation for specialist services for mental health, acute care, rehabilitation, drug alcohol withdrawal, and peri-natal inpatient units alongside outpatient, 'front-of-house', and office and support activities
Size: 15,000 m^2. **Cost**: AUD$130 m. Cost per m^2 = (130 m/15,000). **Type of Construction**: New Build. **Procurement route**: Construction Management (CM) involving the selection of a Managing Contractor (GC21 Construction Contract Edition 1) via a competitive tender for services and fees. The contractor is appointed early in the detailed design and documentation phase of the project. **Project Team**: Commissioning Client- Appointment: Department for Transport, Energy and Infrastructure, Sponsor: South Australia Health, Architects- Medical Architecture UK, Swanbury Penglase Architects, Adelaide Australia. **Other Collaborators**: CM + Urban Designers, M&E Engineers: BESTEC, Structural Engineers: KBR, Cost Consultants: Rider Levett Bucknall; Construction: Hansen Yuncken
Implementing evidence-based design principles and corresponding interventions: To • Create a place of refuge, safety, security and healing, i.e., place-making that ensures the design processes, the proposed layout structure and form provide a development that is appropriate to the local context. • Achieve demystification + destigmatisation, dignity + autonomy and community integration • Provide a high standard of aesthetic quality and park-like settings evident in 'Village-like' configuration, Courtyard buildings that emphasise views, connection and access to nature and outdoors whilst avoiding use of extensive external fences for security • Accommodates diversity and ensures that the re-development supports a vibrant, diverse and inclusive community that integrates well with neighbours or surrounding communities
Post-Occupancy Evaluation: Aims to evaluate the design of the new healthcare facilities in their ability to meet the requirements of the new Model of Care. This provides evidenced-based proof that the redevelopment was worthwhile and beneficial
Sustainability credentials: Demonstration of leading transformative practice in sustainable design and construction. Application of the principles seeks to enhance the ecological value of the Campus via sustainable building that delivers and achieves an improved indoor environment and contributes to a healthy building. A Project Collaborative Workgroup that will also be responsible for on-going monitoring and assessment established **Sustainability Key Result Areas** with measurable **performance targets** for **Energy** (0.86 MJ/m^2 per annum) to reduce energy consumption, ***Water** (0.25 kL/m^2 per annum) to reduce water usage, **Daylight** (Daylight factor of 2 or greater achieved in excess of 45 % of regularly occupied spaces) to ensure adequate daylight penetration in all habitable rooms and **Waste** (A minimum of 80 % reduction in construction waste destined for landfill) including recycling and re-uses of waste generated
Environmentally sustainable design initiatives: Glazing Design—Double glazing specified in critical comfort areas, Insulation—Building material properties to exceed BCA Standards by 20 %, **Daylight**-Simulations undertaken to optimise relationship between daylight penetration, solar glare and solar heat gains, **High efficiency, high-frequency fixtures** chosen to reduce health-issued associated with low-frequency flickering, Low VOC **Materials Low + Formaldehyde** products adopted to maintain a high standard of indoor air quality, **Internal Noise Levels** assessment, **Sub-metering** used on all energy uses above 100 kVa, **Lighting Power Density** minimised with AS/NZS 1,680 requirements met, Lighting Zoning – All individual and enclosed rooms separately switched, Automated lighting controls used in staff areas, **Efficient external lighting** specified, **Openable windows** in all client areas + widened set points in office areas, **Automated off HVAC Controls** to improve energy efficiency, **Renewable Energy Generation** -5 kW Photovoltaic installation, **Water efficient fixtures and fittings** specified, **Rainwater harvesting** used for all flushing requirements, **Reclamation of contaminated** land, **Vegetated swales + sensitive planting** schedule allowing for drought-tolerant landscaping, retention + enhancements of biodiversity, **Ample bicycle storage** provision to encourage alternative transport, **All refrigerants** used in HVAC have a zero Ozone Depletion Potential, **Light pollution** minimised, **Construction Waste Landfil**l diversion, **Portland cement substitution**—30 % in situ, 20 % pre-cast and 15 % stressed concrete, Use of **recycled materials, Environmental Management Plan** implemented
The intention is for a benchmark for sustainability in terms of demonstratable environmental performance of a solution for a particular site and context thereby providing an alternative approach to using star rating methods such as the 'Green Star' System by Green Building Council Australia or scoring of points prevalent with many Building Assessment Systems

Option 5:—Village Option a 'Village-like' configuration in which a number of separate buildings are arranged around a common shared garden. Inpatient facilities are then organised into separate residential blocks (single-storey residential scale + using domestic materials and construction methods) with a more commercial 'front of the house' building housing administration and educational functions that represents the first point of contact for everyone arriving on the campus (Figs. 4.88, 4.89, 4.90, 4.91, 4.92 and 4.93).

Historically, the debate in mental health of what, how and where accommodation should be provided has centred on either segregating communities or integrating them, i.e., either isolated segregated settings with locked wards or facilities that are part of the community with open wards allowing voluntary patients to exit them freely. The key considerations have been incorporating specific design features, for example, the definition of the boundaries or perimeter and the extent of the separating geographical distances that symbolise the 'carceral' function, analogous to a prison, 'designed to exert control over patients and to "protect" society from contact with psychiatric patients who have been represented as "dangerous" and "undesirable" in their behaviour' (Curtis et al. 2009).

Consequently, as a result, we see developments on one hand of out-of-town rural or countryside (often remote) location of facilities which although gated with an imposing 'fortress' solid wall perimeter that also imply protecting people with mental illnesses against the risks of abuse, stigma or corruption (external hazards) which they are vulnerable in the wider community yet comprise generous landscaped areas within. On the other hand, we have developments of mental health facilities located within the community particularly in inner city areas with a much more permeable ill-defined boundary or interface. In this case, design solutions have also focused on whether the facilities should be small-scale and more



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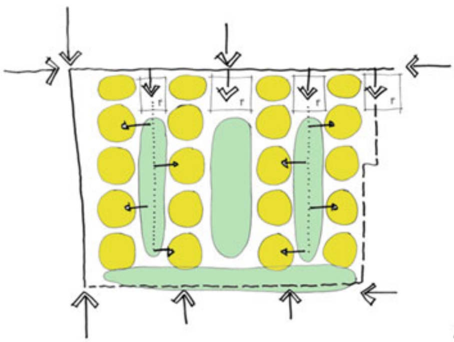

4.

Fig. 4.89 Glenside Campus Redevelopment Australia—Options for site configurations: *3* Urban option—A grid and an extension of the suburb street scene, integration into the community but having own individual address, yet high-density and city park, *4* Villas option—A series of similar sized buildings is arranged around private gardens typically defined by the 'Almshouse Model' (*Source* Swanbury Penglase Architects 2012)

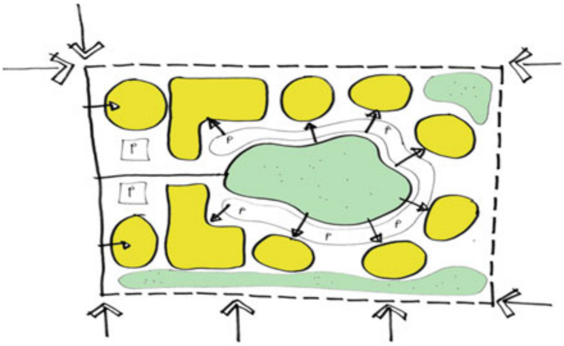

Fig. 4.90 Glenside Campus Redevelopment Australia—Options for site configurations: *5* Village option or a 'Village-like' configuration—A number of separate buildings are arranged around a common shared garden. Inpatient facilities are then organised into separate residential blocks (single storey residential scale + using domestic materials and construction methods) with a more commercial 'front of the house' building housing administration and educational functions that represents the first point of contact for everyone arriving on the campus (*Source* Swanbury Penglase Architects 2012)

Fig. 4.91 Glenside Campus Redevelopment Australia—'Village Common or Green': a common shared green space provides an external area for social activities that help nurture and foster the community spirit while increasing up take of physical activity. The Village Green specification is for a shared soft landscaped space with recreation/sports surface that is capable of handling organised events, informal sports and providing a general village focus. (*Source* Swanbury Penglase Architects 2012)

Fig. 4.92 Glenside Campus Redevelopment Australia—Overall Site Plan: the ‘Village-like’ configuration has a number of separate buildings are arranged around a common shared garden access and circulation routes have been designed to facilitate easy way finding, navigation and observation. The master plan promotes the integration of public art throughout the campus redevelopment to reinforce the unique historical and cultural setting of the Glenside Campus and to enrich the public domain for both the general public as well as users of the new mental health and substance abuse facilities. (*Source* Medical Architecture UK + Swanbury Penglase Architects 2012)

manageable or larger units offering access to a wide variety of diagnostic and treatment regimes or therapies.

In all the above-mentioned situations, the model of care as opposed to the physical model indicating the role of the built environment has been an important underlying and defining salient element specifically whether patients recover from their illness and will then be able to go back to the community or will forever remain incarcerated.

2. *Creating a place of refuge/sanctuary, safety, security and that supports recovery and healing*: A key issue for the design of new inpatient mental health units is to understand and recognise the nature of the links between an acute inpatient facility and its local community and to accommodate both patients’ requirements and those of the community. As a piece of ‘civic architecture’ in a functional as well as aesthetic sense the building needs to be designed to foster links with the community it serves (Curtis et al. 2009).

Fig. 4.93 Glenside Campus Redevelopment Australia—‘Park-like’ settings: help engender impressions that this is a place of refuge, safety, security and healing in so doing achieve demystification + destigmatisation. (*Source* Swanbury Penglase Architects 2012)

Furthermore, for the patients or people with long-term mental illnesses, there is a case for acknowledging the significance of the psychiatric hospital as a relatively stable feature in the otherwise insecure and unpredictable geographical experience and continuum of care, and for determining how the correct balance is to be achieved between providing a caring and supportive institutional environment while being able to ensure that the patients are successfully returned to the community when they are ready (Curtis et al. 2009). This makes it vital to create a homely atmosphere with conditions which help patients to be discharged, in a timely fashion, into settings where a degree of medical control and ‘discipline’ is perceived to be either limited or weaker than in the hospital.

For the wider community, the need is to increase our understanding of the nature of mental illness and provide reassurance that is not necessarily evident in physical segregation dominated by extensive security fences or masonry boundary walls.

The inpatient facilities for the Glenside Project aim to address some if not all these issues by providing clusters of ‘pods’ consistent within a widely adopted practice in Australia though not unique to Australia. Each pod is then organised around its own enclosed garden that enhances privacy and security but avoids the need for further unnecessary external security fences that separate the facilities from its wider community.

Fig. 4.94 Glenside Campus Redevelopment Australia—Typical Inpatient Unit: Single-bedded rooms with en suite toilet/shower have been provided for safety reasons, to avoid violations of privacy, dignity and confidentiality and to enhance bed management flexibility, efficiency and effectiveness. The inpatient facilities are configured as 4 separate units of varying occupancies, each consisting of a number of conjoined 'pods' (except for the Helen Mayo House). Each pod consists of a number of bedrooms (8–10), arranged around a courtyard. Designed for security for consumers without creating a sense of detention or incarceration the landscaped courtyards (typically 14 m long by 10 m wide) provide a high quality therapeutic environment offering a range of outdoor spaces for sitting, walking and contemplation (*Source* Medical Architecture UK + Swanbury Penglase Architects 2012)

3. *Inpatient Residential Units, Disposition of Bedrooms and Access to and from Shared/Day Spaces*: Identifying and defining these elements seems to be fundamental for the creation of therapeutic landscapes that impact on factors for the well-being of patients, staff and visitors in mental health facilities. Of importance are spatial configurations that provide a hierarchical sequence of spaces progressing from private and secure to public and supporting the model of rehabilitation for consumers; from the ultimate privacy of consumer's bedrooms through to full engagement with the public realm. Such design aims to foster autonomy and provide support for a recovery-focused model of health care (Figs. 4.94, 4.95, 4.96, 4.97, 4.98, 4.99, 4.100).

For the inpatient units in the Glenside Project, key considerations and design principles include the following:

- The creation of secure and private gardens using the building form and massing.
- Locating bedrooms along the perimeter of the building.

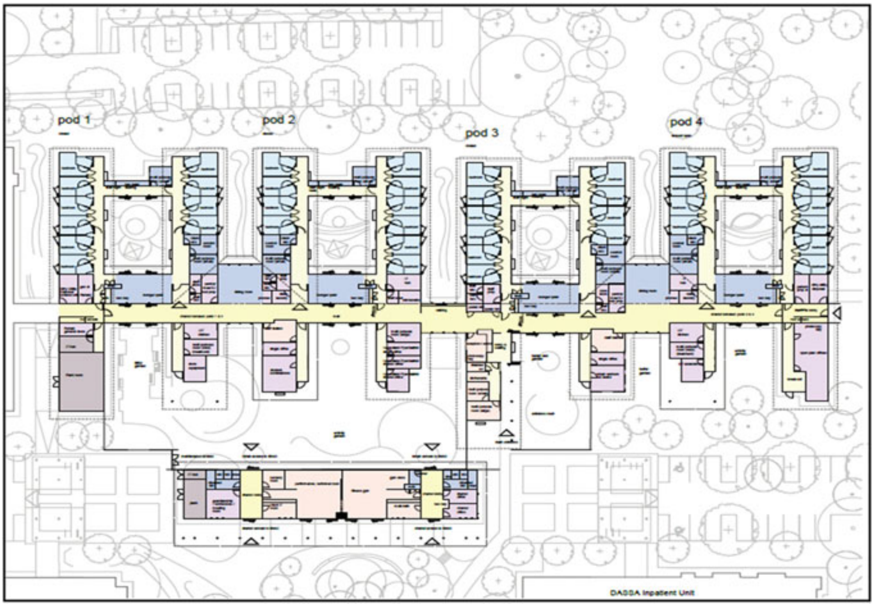

Fig. 4.95 Glenside Campus Redevelopment Australia—Ground Floor Plan: Rehabilitation Service and Activity Centre (*Source* Swanbury Penglase Architects 2012)

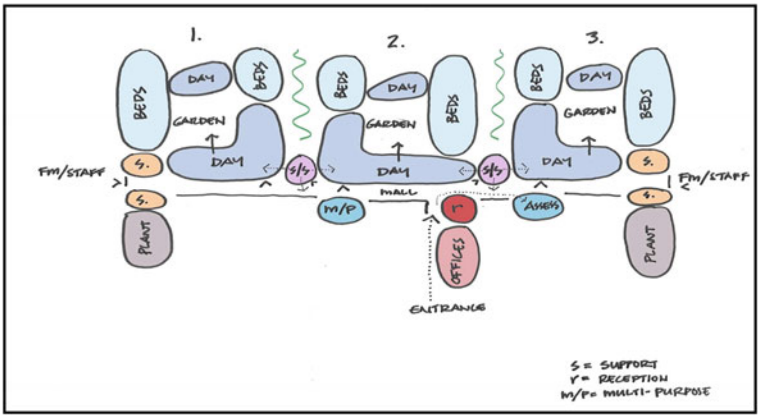

Fig. 4.96 Glenside Campus Redevelopment Australia—Drug + Alcohol Services South Australia Bubble Diagram: Spatial organisation is designed to facilitate interrelationships and adjacencies or interdependencies (*Source* Medical Architecture UK + Swanbury Penglase Architects 2012)

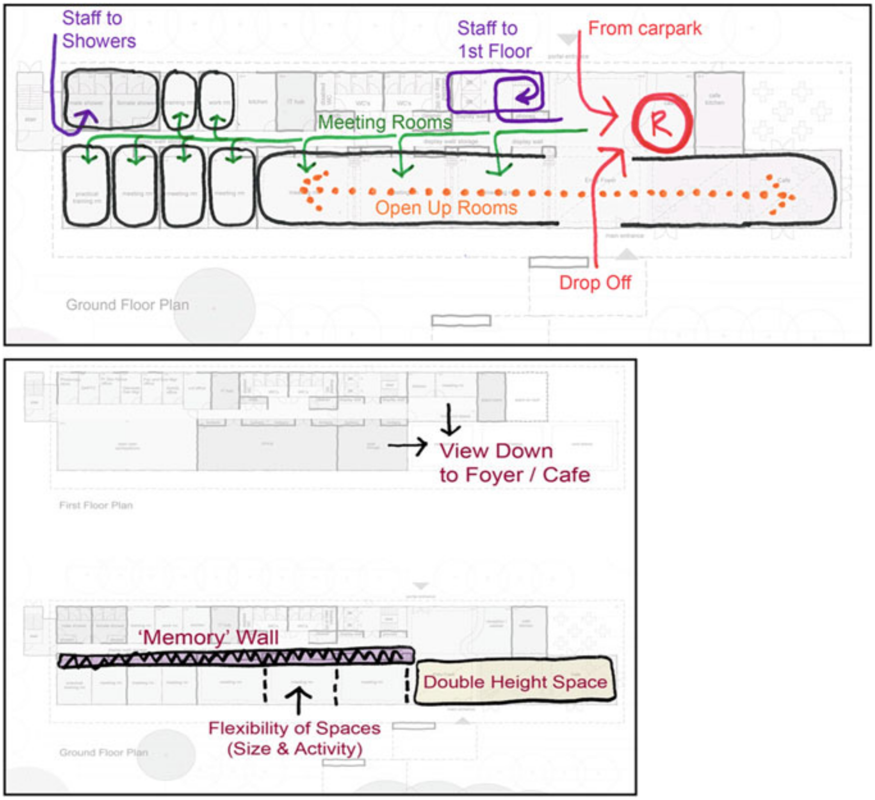

Fig. 4.97 Glenside Campus Redevelopment Australia—'Front of the House' Sketch Plan: Access and circulation routes have been designed to facilitate easy way finding, navigation and observation. The building's foyer provides and enhances opportunities to exhibit works of art, sculpture by the patients, staff and local artists including artefacts of historical significance to Glenside (*Source* Medical Architecture UK + Swanbury Penglase Architects 2012)

- Providing main day spaces with views out onto the garden while more discreet day rooms are located around the outer edge with views outwards beyond the healthcare facilities.
- A mall or precinct that acts as an internal street connecting entrance to the pods and the shared spaces such as the main entrance and support accommodation.
- Using the junctions between pods to create gathering and shared spaces. 'Spaces of transition' such as corridors and reception areas are important for hospital design because they foster links with the community (Douglas and Douglas 2009) by allowing mixing of those using healthcare services, visiting and working in the facility (Figs. 4.101, 4.102, 4.104, 4.106, 4.107, 4.108).

Locating shared 'public' accommodation in a series of fingers off the mall, thereby offering a variety and mixture of external spaces in between. In this case,

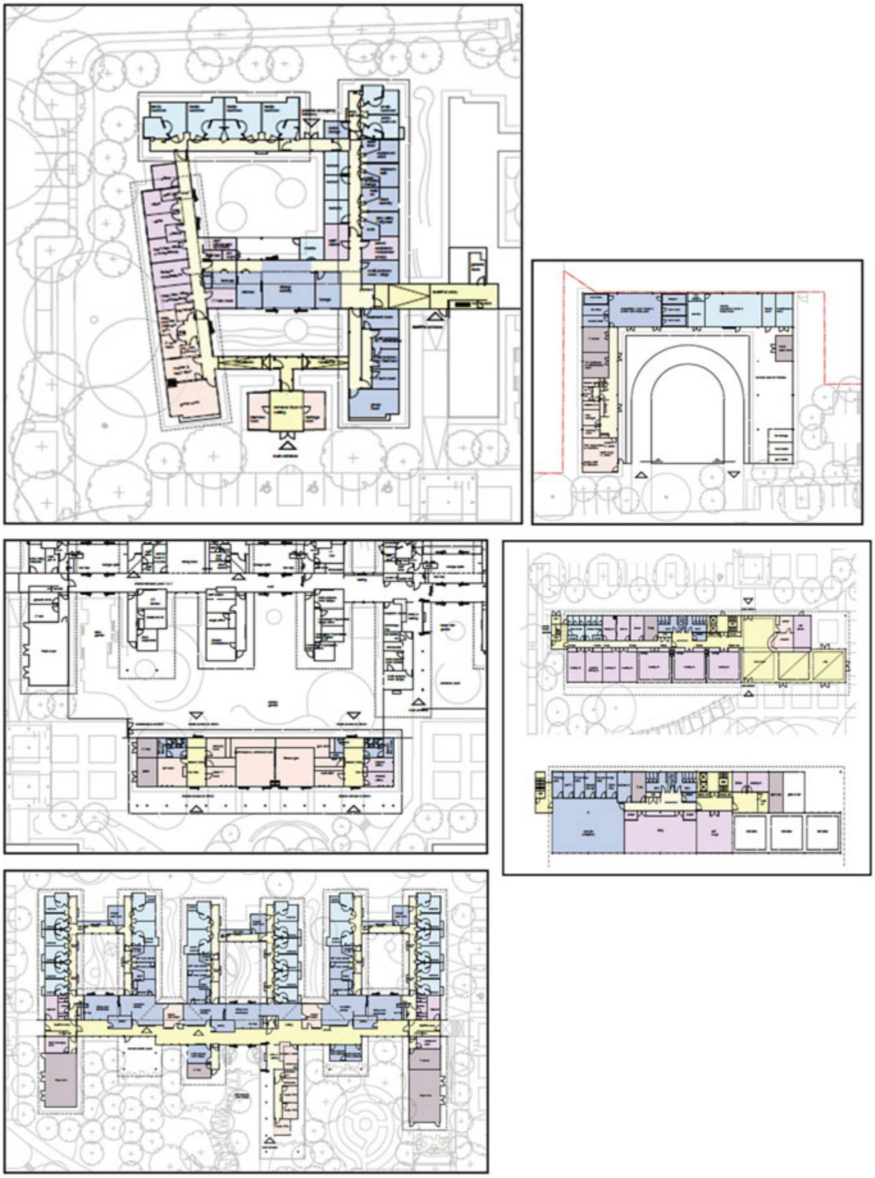

Fig. 4.98 Glenside Campus Redevelopment Australia—Floor layout of the inpatient unit + shared accommodation: access and circulation routes have been designed to facilitate observation. A typical unit has 3 or 4 pods linked by a generous corridor with the character of an internal 'mall'. The mall gives access support to spaces such as administrative and consulting offices as well as providing a 'front door' or main point of access (*Source* Medical Architecture UK + Swanbury Penglase Architects 2012)

Fig. 4.99 Glenside Campus Redevelopment Australia—Inpatient unit internal garden: semi-public external space that promotes safety, privacy + dignity, autonomy, improving sense of self-worth and motivation of self-care (consistent with the aim of treatment that helps patients regain their capacity + ability to live successfully in the community) + aiding recovery (*Source* Swanbury Penglase Architects 2012)

activity 'activates' the shared healing garden that involves background animation, while the 'front-garden' model also provides a degree of self-policing (Figs. 4.103, 4.105, 4.109).

In mental health compared with other areas of the healthcare sector, there has been a general early acceptance of providing single-bedded rooms for various reasons notably of safety whether this is of the patient or other patients in shared accommodation, of avoiding violations of privacy, dignity and confidentiality, of reducing the prospect of giving the wrong medication because the patient is confused with a roommate, of enhancing bed management flexibility, efficiency and effectiveness (Phiri 2004; Lawson and Phiri 2003) including making sure that male and female patients have roommates of the same sex and of producing harmful stress which impedes recovery and the healing process.

The main aim in providing the single-bedded inpatient rooms has therefore not necessarily been to reduce infection rates or to reduce susceptibility to disease transmission or exposure to airborne infections that could waft over from a roommate (Crimi et al. 2006; Jiang et al. 2003; Hahn et al. 2002; Ben-Abraham et al. 2002; McManus et al. 1992).

4. *Demystification + Destigmatisation, Dignity + Autonomy and Community Integration*: One challenge for Providers of mental health services is overcoming the social stigma associated with mental illness and this includes breaking down the connotations of old spaces of care or the stigma associated with existing facilities such as the Victorian Asylums and their strong inferences to the physical restraint on the behaviour of people with mental illnesses.

Fig. 4.100 Glenside Campus Redevelopment Australia—Spatial layout + access: incorporates semi-public external space that promotes safety, privacy + dignity, autonomy, improving sense of self-worth and motivation of self-care (consistent with the aim of treatment that helps patients regain their capacity and ability to live successfully in the community) while aiding recovery (*Source* Swanbury Penglase Architects 2012)

In the Glenside Redevelopment Project, one way to overcome the social stigma or de-stigmatise the existing site and its Victorian Asylum references is to provide courtyard buildings of a domestic scale arranged around a shared central 'healing garden' which is then accessible to both patients and the public alike. The facilities are configured so as to provide privacy and security for service users, fostering autonomy, improving sense of self-worth and motivation of self-care (consistent with the aim of treatment that helps patients regain their capacity and ability to live successfully in the community) and supporting a recovery focused model of health and social care (Figs. 4.110, 4.111).

5. *High Standard of Aesthetic Environmental Quality Park-like Settings*: Many studies have highlighted the need for the built healthcare environment as well-designed landscaped places which incorporate the provision of therapeutic features or properties of nature for the purposes of patient healing, family gathering, relaxation and privacy (Nordh et al. 2009; Van den Berg et al. 2007; Sherman et al. 2005; Varni et al. 2004; Taylor et al. 2001, 2002; Kaplan and Kaplan 1989).

A therapeutic feature typical of the Victorian Asylums was the large psychiatric hospital grounds where patients could walk freely outside while still within the

Fig. 4.101 Glenside Campus Redevelopment Australia—Spaces of transition such as corridors and reception areas are important for hospital design because they foster links with the community (*Source* Swanbury Penglase Architects 2012)

Fig. 4.102 Glenside Campus Redevelopment Australia—Spaces of transition 2 such as corridors and reception areas are important for hospital design because they foster links with the community (*Source* Swanbury Penglase Architects 2012)

confines of the hospital. Studies show that people who have been in residential care in long-term institutions retained a sense of attachment to these grounds and visited them even after the hospitals were closed (Parr et al. 2003).

The Glenside Project embraces findings from all these research studies prioritising on the development of Park-like settings that are created using the spatial layout, building form, the choice of materials, textures including type of plants to be provided, fixtures and external furniture through to providing a vision of how these settings will look when completed and mature, how they will be used and adapted to accommodate a variety of activities and how they will be managed to enhance recovery and healing.

6. *Accommodating Diversity*: This ensures that the re-development supports a vibrant, diverse and inclusive community that integrates well with the surrounding communities. The Glenside Re-development seeks to do this through making a meaningful contribution to the sustainable economic viability of the local area, the South Australian country and Eastern Metropolitan Adelaide regions. This is facilitated by compliance with key guidance and design codes including The Australasian Health Facility Guidelines (Aus HFG); The SA Government Office Accommodation Framework; The Building Code of Australia (BCA) & Disability Discrimination Act (DDA); SA Health Facilities Design Standards & Guidelines & Environment Design Parameters for Health Buildings; Department of Planning Transport and Infrastructure (DPTI) Publications, Policies & Guide Notes; DPTI-Ecologically Sustainable Development Planning, Design & Delivery G44; Environment Protection Authority (EPA)—General Code of Practice for State & Federal Government Agencies for Storm Water Pollution Control; and Water Sensitive Urban Design Guidelines.
7. *Art*: In order to enhance and contribute to the healing environment healthcare spaces must feature programmes for art including but not limited to stained glass, paintings, photographs, murals, sculptures, water features, ceiling designs and donor recognition areas. Art in public places offers distractions, free and enriching experiences (Belver and Ullan 2011; Cusack et al. 2010; Staricoff et al. 2003). Introducing art in previously sterile spaces enhances aesthetics while providing opportunities for therapy and capacity to connect with the others.

In the Glenside Project, a gallery-type space in the 'front of the house' building's foyer provides and enhances opportunities to exhibit works of art, sculpture by the patients, staff and local artists including artefacts of historical significance to Glenside. This helps strengthen ties with the local community while encouraging integration.

There is a budget allocated for integrated art works for the Precinct 1 New Health Facilities of $250,000. Following receipt of seed funding ($15,000) from Arts SA, an expression of interest was called for artist teams to respond to an *Integrated Public Art Brief* developed by Swanbury Penglase Architects specific to the new health facilities. In so doing, SA Health encouraged applications from

Fig. 4.103 Glenside Campus Redevelopment Australia—Gallery: Offers opportunities to exhibit works of art, sculpture by patients, staff and local artists including artefacts of historical significance to Glenside (*Source* Swanbury Penglase Architects 2012). The central facility administration offices and educational facilities are accommodated in a commercial scale building at the west end of the site, and will act as the public face to the facilities

artist teams with experience, insight or interest in mental health or drug/alcohol related conditions. The selected artist team has completed the design development phase and presented three discreet proposals for integrated works of art that respond to the unique setting of the Glenside Campus and which support the therapeutic principles within and around the new health facility buildings. The three concepts comprise (1) A water feature located in the central and semi-public shared garden; (2) Glass installations within high-traffic areas of the buildings; and (3) Sculptural privacy screens situated on external edges of the buildings. SA Health has also commissioned one to the artists to document the project photographically with a view to potential displays on site and or publication.

8. *Ecological sustainability incorporating bioretention and overland swales as well as rain water garden*: A single project such as this one for a mental health facility poses many challenges on how to implement the multi-facets of sustainable development usefully indicated by interrelated environmental, cultural, social and economic factors. In practice design teams have conveniently focused on sustainable building and sustainable building-in-use facilitated by going for star ratings including Green Star by Green Building Council Australia or scoring of points under a variety of building assessment systems. The Chapter on Guidance and Tools refers to this as 'points chasing'—a process of seeking the greatest number of points under the assessment systems for the least

cost, regardless of environmental benefit. The Glenside Project has therefore adopted an alternative approach which at the same aims to address these criticisms of the building assessment methods.

Glenside Campus Re-development demonstrates leading effective practices in Australia of sustainable design and construction. In this case, design for sustainability aims to further improve energy efficiency, reduce greenhouse carbon emissions while enhancing the ecological value of a Campus that delivers and achieves:

- An improved indoor environment and contributes to a healthy building. This includes ensuring that the design of individual buildings does not undermine the sustainability of the overall development.
- Drought-tolerant landscaping and Water-sensitive urban design which takes into account the rainfall received in the area, potential for flash floods incorporating rainwater harvesting, grey water harvesting and biofiltration through natural means to enhance the site aesthetics and biodiversity credentials.
- Improvement in energy efficiency.
- Reduction in carbon emissions.
- Implementation of renewable power generation with minimal 10 KVA solar array per shack.
- Reduction in waste including recycling and re-uses of waste generated during construction. This promotes the sustainable use of resources including water, materials and waste, both in construction and in operation.
- Retention and enhancements of biodiversity ensures that the ecological value of the site is not damaged but is conserved and enhanced thorough the creation of a variety of different habitats.

The intention is that for a benchmark for sustainability in terms of real performance and a solution that is tailored to the site and context as alternative approach to going for 'star' ratings or scoring of points in which a high score may not necessarily correlate with the best environmental solution on a project-by-project basis.

Design for sustainability involved setting up of a Project ESD Workgroup for the Glenside Campus Redevelopment Healthcare Facilities that established Environmentally Sustainable Design (ESD) initiatives and measurable targets that would act as evaluation criteria for the redevelopment project (Precinct 1). The initiatives and targets are the result or outputs from 9 workshop sessions of the Project ESD Workgroup during the period November 2008 to November 2010. The Project ESD Workgroup, which began by establishing Sustainability Key Result Areas with measurable performance targets for Energy, Water, Daylight and Waste, would also be responsible for the on-going monitoring and assessment of the initiatives and targets under an agreed governance framework (Tables 4.24).

The major sustainability aim to develop Glenside as a sustainable urban development leading practice in sustainable design and construction envisions living streets and green space design throughout the site that would encourage walking, physical activities and time spent outdoors. Public design features would add vibrancy to the community and contribute to a better quality of life by

Fig. 4.104 Glenside Campus Redevelopment Australia—Covered terrace overlooking the shared garden encourages activities to spill outside (*Source* MAAP—Medical Architecture UK 2012)

improving safety and security, promoting economic vitality, increasing marketability, enhancing community networks, creating a sense of place and identity, facilitating cultural activities and providing easy access thus achieving a more sustainable environment.

The adoption of an integrated and site-wide strategy ensures that throughout project development communication and cooperation are maximised between precincts to efficiently deliver a cohesive and truly sustainable outcome. Shared precinct initiatives to further improve energy efficiency, reduce greenhouse emissions and enhance the ecological site value of the campus include: Contractor Environmental Management Plan, Materials/Waste sharing, Demolition material re-use, Water harvesting and Water Sensitive Urban D, Renewable Power Generation, Shared infrastructure, Shared reticulated services, Shared Thermal Systems, Access to Public Transport, Landscape and Lighting (Table 4.24).

9. *Consultation Process Involving Users and Stakeholders*: Of importance and underlying the evidence-based design is the robust collection of evidence and validation through a rigorous process. In the Glenside Re-development, widespread consultation with users and stakeholders using a series of interactive workshops was crucial to ensure that the finished facility was of the highest design quality and that it responds to the specific changing needs of clients or consumers from South Australian country regions and the eastern metropolitan Adelaide region. Consulting users and stakeholders offers opportunities for ownership of the problem of sustainability, learning about sustainability or specifically increasing our understanding of the relevance of renewable energy, waste and water management with this enhances the prospect of meeting targets on sustainability.

Table 4.22 Glenside Campus Redevelopment Australia—Environmentally sustainable design initiatives and sustainability key result areas defined by measurable performance targets for energy, water, daylight and waste were established by a project collaborative workgroup which is also responsible for on-going monitoring + assessment

	Glenside key result area measurable performance targets > best practice	Authoritative source, basis and rationale
Energy	*0.86* MJ/m^2 *per annum* for annual energy consumption	*The SA Strategic Plan 2007* mandates a reduction in energy use by the Government building of 25 % by 2012 based upon 2000/2001 levels and also the limiting of the State's greenhouse emissions by 2012 of 1990 levels as a 1st step towards a 60 % reduction by 2050. Best Practice (50–74 %) value is 1.43 GJ/m^2
Water	*0.25* kL/m^2 *per annum* for annual portable water targets	83 % reduction compared to portable water targets established for existing acute facilities by SA Health 2008 and a 72 % reduction compared with the SA Health target for small acute hospitals. Best Practice (50–74 %) values are Large Acute Hospitals 1.38 kL/m^2 and Existing S*mall Acute Hospitals* 0.9 kL/m^2
Daylight	*Daylight factor of 2 or greater achieved in excess of 45 % of regularly occupied spaces*	A daylight factor of greater than 2.0 over more than 60 % of the usable floor area, the assessment of the impact of glazing design and external shading on a representative Rehabilitation Building against the *Green Star, Office v3, IEQ-4 Daylight Criteria* demonstrated a very good level of natural daylight penetration Best Practice (50–74 %) values are a daylight factor of 2 or greater achieved in excess of 30 % of regularly occupied spaces
Waste	*A minimum of 80 % reduction in waste destined for landfill*	To achieve a best practice in Construction Waste Management, *a waste minimisation strategy* was adopted for the Glenside Campus Redevelopment to promote recycling and reuse of demolition waste material but excluded hazardous materials and contaminated soil Best Practice (50–74 %) value is 80 % construction waste diverted from landfill

Source Cundall + Swanbury Penglase Architects 2012

Table 4.23 Glenside Campus Redevelopment Australia—Environmentally sustainable design initiatives—the result of 9 workshop sessions during the period November 2008 to November 2010

Environmentally sustainable design: initiatives		
Built Form to deliver an improved indoor environment + a healthy building	Glazing design	Glazing design optimises the relationship between natural day light penetration and solar heat gain. 2 key factors considered in glazing design are glazing size and façade orientation. Double glazing is specified in critical comfort areas to improve thermal performance of the built form. Also considerations are direct sunlight minimisation via external shading, connection to the outdoors via openable windows, and provision of single-loaded corridors
	Insulation	Building material properties (i.e. glazing and insulation) to exceed BCA (Building Code of Australia) Standards by 20 % and to promote building performance and reduce HVAC demand
	Embodied energy minimisation	Sustainable material selection using comparative product assessments undertaken throughout the design process
Indoor environment quality to promote health and well-being of occupants	Daylight	Daylight simulations undertaken to optimise relationship between daylight penetration, solar glare and solar heat gains
	High-frequency lighting fixtures	High efficiency, high-frequency fixtures chosen as standard practice (to reduce health-issued associated with low-frequency flickering)
	Low VOC materials	Low Volatile Organic Compounds (VOC) adopted as standard practice to maintain a high standard of indoor air quality
	Formaldehyde minimisation	Low Formaldehyde products specified as standard practice to maintain a high standard of indoor air quality
	Internal noise levels	Acoustic consultants engaged to assess internal noise levels and help minimise noise pollution from HVAC equipment, adjacencies and traffic
	Indoor plants	Provision of indoor plants as an effective biofiltration system to purify air quality

(continued)

Table 4.23 (continued)

Environmentally sustainable design: initiatives		
Energy achieving total predicted energy use of 861 MJ/m^3 annually, a 25 % reduction (per m^2) compared to the Repatriation General Hospital	Sub-metering	Sub-metering used on all energy uses above 100 kVa to provide data for reprogramming the Building Management System (BMS) that facilitates energy optimisation and efficiency
	Lighting Power Density	Maintenance of AS/NZS 1,680 requirements but targeting best practice design to minimise lighting power density
	Lighting Zoning	All individual rooms and enclosed rooms separately switched to provide a greater flexibility over light switching control enabling a more energy-efficient approach to lighting management
	Automated lighting controls	Automated lighting controls used in staff areas to ensure that artificial lightings is only operated during times of occupation. Client areas including bedrooms remain manually switched
	External lighting	Efficient external lighting with no light pollution used
	HVAC systems	Openable windows in all client areas + widened set points in office areas. Although installed as required by the client the mechanical HVAC system is to remain predominately inactive throughout the year only to operate when weather conditions render the passive systems ineffective
	Automated off HVAC Controls	Use if sensors to improve energy efficiency. An options evaluation study determined that conventional air-cooled, reverse cycle fan coil units' best suited the HVAC control strategy for the project
	Renewable Energy Generation	Roof-mounted 5 kW Photovoltaic (PVs) installation will result in savings in greenhouse gas emissions of 8,500 CO_2/annum

(continued)

Table 4.23 (continued)

Environmentally sustainable design: initiatives		
Water—annual predicted potable water use including rainwater storage + reuse of 0.25 kL/m^2	Water management strategy	Water Management resulting in an annual predicted potable water use including rainwater storage + reuse of 0.25 kL/m^2, an 83 % reduction (per m^2) compared with existing Glenside facilities equal to over 18 Olympic-sized swimming pools per annum or an 83 % reduction (per m^2) compared to the Repatriation General Hospital. Approach adopts waterless landscaping via native vegetation
	Fixtures + fittings	Water-efficient fixtures and fittings specified using a selective Purchasing Plan and selecting fixtures with a minimum 4 Star WELS rating
	Rainwater harvesting	Rainwater harvesting used for all flushing requirements on site. Approximately 52,000 l captured stored in a tank located centrally on the site allowing re-use for harvesting annually
Ecology to minimise impact on local ecological systems and biodiversity	Reclamation of contaminated land	All necessary steps taken to remediate any contaminated land. Potential wetland creation is seen as a ecological value enhancing scheme through improved land use and providing native vegetation and wildlife diversity
	Vegetated swales	Vegetated swales in areas such as car park surrounds will aid the local ecology by filtering surface runoff and maximising the time water spends in the swales in the process trapping silt and pollutants before entering local storm water catchment areas
	Sensitive planting	Vegetated swales and a sensitive planting schedule implemented to aid the local ecology
Transport to reduce emissions	Cycling facilities	Ample bike storage provided to encourage alternative transport. Landscaping and infrastructure have been developed to have the capability of linking into Adelaide's expanding Public Transport System and reducing the site's carbon and environmental footprint. Car use reduction creates growth opportunities

(continued)

Table 4.23 (continued)

Environmentally sustainable design: initiatives		
Emissions to be targeted and related impact on the environment	Refrigerant emissions	All refrigerants used in HVAC have a zero Ozone Depletion Potential (ODP)
	Light pollution minimisation	No external light beams directed beyond or upwards of site boundary
	Legionella minimisation	No cooling towers used thereby eliminating risk of *Legionella* outbreaks
Materials to optimise the relationship between functionality + environmental impact	Construction Waste Landfill diversion	A minimum of 80 % reduction in waste destined for landfill to be achieved
	Cement substitution	Portland cement substitution—30 % in situ, 20 % pre-cast and 15 % stressed concrete provides a significant reduction on the embodied carbon and energy for the project
	Recycled materials	Use of recycled materials where possible such as in plasterboard and insulation (no on-site recycling of products to be undertaken)
Management to ensure a focused and continual commitment	Environmental management plan	A focused and continual commitment is critical to fulfilling and maximising returns on the sustainable aspirations of the project - through adoption of site management measures and implementing an Environmental Management Plan (EMP) which sets site wide targets for Waste, Water and Energy Consumption and identifies appropriate meeting and monitoring processes

Source Cundall + Swanbury Penglase Architects 2012

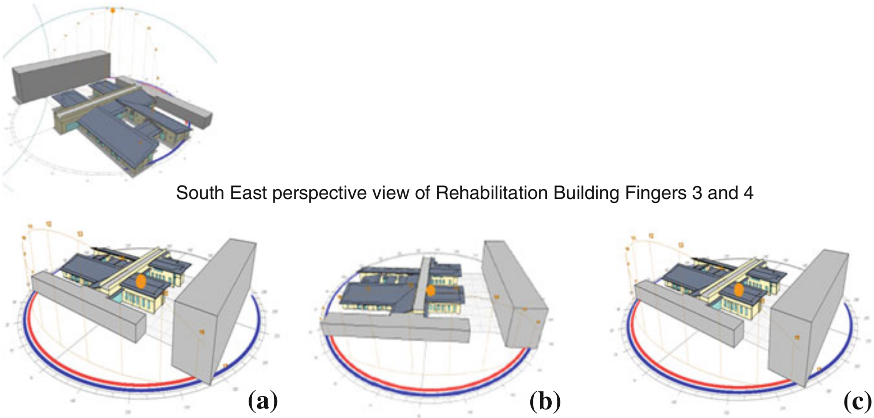

Fig. 4.105 Glenside Campus Redevelopment Australia—Rehabilitation building solar access study—The rehabilitation building is representative of a larger portion of buildings on site and whose study helped inform the design of the other buildings. Daylight simulation + analysis showed that the majority of areas, particularly the bedrooms with their bay type windows, lounge and malls areas all have excellent access to daylight. Typically A = View from sun position, winter, 9:00 am; B = View from sun position, winter, 12:30 pm; C = View from sun position, winter, 2:30 pm (*Source* Cundall + Swanbury Penglase Architects 2012)

Fig. 4.106 Glenside Campus Redevelopment Australia—Spaces of transition 3 such as corridors and reception areas are important for hospital design because they foster links with the community (*Source* Swanbury Penglase Architects 2012)

Table 4.24 Glenside Campus Redevelopment Australia—Schedules of the minimum environmentally sustainable design governance requirements

Glenside campus healthcare facilities: Environmentally sustainable design governance
Schedules of the minimum Environmentally Sustainable Design Governance requirements
Additional Governance requirements may be specified or inferred in current terms and conditions of engagement. It is not the intent of this document that these requirements are superseded. The intent of this document is to provide DTEI with a short form checklist against which the content of the current contracts can be validated
• Provision of monthly Environmentally Sustainable Design reports to the IMT. The minimum content shall be: confirmation of Environmentally Sustainable Design in design, meeting site works Environmentally Sustainable Design targets, and confirming that the required outcomes will be met. Site works Environmentally Sustainable Design targets shall include but may not be limited to:
– Diversion of waste from landfill
– Re-use of construction waste on site
– Balance cut and fill
– Use of materials
– Use of site energy and water
– Schedule of sub-contractor inductions
– Restriction of site noise
– Restriction of site pollution (air, soil, water)
• Provide corrective action reports and undertake corrective action required where any deficiencies have occurred (for example, lower than required diversion of construction waste to landfill)
• General design and documentation issues including FF&E and fit-out. The procurement of all equipment, materials, products and services must be validated against the Environmentally Sustainable Design Specifications, Reports and Key Result Area's
• Peer review/checking of engineering services documentation and energy modelling and assessment against the Key Result Area criteria. The actual energy, water and emissions performance must be validated against the Key Result Area requirements and Environmentally Sustainable Design specifications/reports
Sub-contractor toolbox talks. All sub-contractors must be contracted to comply with the specified Environmentally Sustainable Design requirements including regular reporting. Undertake toolbox talks and detailed briefings
• Verify all commissioning activities and ensure that all systems are fully functional and commissioned prior to handover
• Adopt a 'soft landings' approach to hand over and occupation and ensure that user feedback is obtained so that systems can be tuned as necessary to ensure optimal operation

Source Cundall + Swanbury Penglase Architects 2012

10. *Post-occupancy evaluation* (POE): The project team is hoping to establish a demonstrable improvement in operational and healthcare outcomes, within an established and internationally recognised evaluation framework, the POE seeks to provide evidenced-based proof that the redevelopment has been worthwhile and beneficial to staff and clients/consumers to further improve the delivery of mental health, and alcohol and other drug services. And if not what should have been done differently in order to provide a legacy for future health service developments (Table 4.25).

Table 4.25 Glenside Campus Redevelopment Australia—Post-occupancy evaluation (*POE*) to establish demonstratable improvement in operational and healthcare outcomes aims to provide evidenced-based proof that the redevelopment was worthwhile and beneficial

Post-occupancy evaluation questionnaire (draft)
1.0 *Respondent information*
1.1 Name
1.2 Position title
1.3 Length of experience in current position
1.4 How long have you worked in the facility (months, years)
2.0 *Planning process*
2.1 Were you involved in planning or design of the facility or part of it, if yes, what was your role?
2.2 Did you participate in any Workgroups or User Groups?
2.3 Was there any other way in which you were involved?
2.4 Please assess the following planning process features (Very Poor – Excellent):
– Level of input
– Clear communication
– Time commitment
– Overall facility/unit design process standard
– Your overall planning process experience
2.5 Comments
3.0 *Team learning*
3.1 Please assess the following criteria for Achievement and Performance (Score 1 Unsatisfactory – 5 Exceptional) and for Importance (H = High, M = Medium or L = Low):
– Development of an integrated health model throuh collocation to:
– Enhance access to services for the community
– Improve effectiveness of services
– Share facilities and services between each service provider
– Achieve internal and external security for staff
– Create a non-institutional development that reflects the surrounding physical and rural environment with buildings appropriately designed for their intended usage
– Provide stimulating views for long-term patients
– Provide an external environment for patients/residents which will:
– Be practical and enhance the utilisation of the site
– Ensure appropriate security, privacy and safety
– Provide appropriate weather protection so that courtyards can e utilised all year round
– Be an extension of the internal recreational and therapy spaces
– Provide facilities which maximise energy efficiency and environmentally sustainable
– Facilities that promote a modern, state of the art mental health centre
– The facilities are complimentary of the heritage values of the site
– Access to surrounding precincts is clear and direct, with enhanced pedestrian amenity
– The facilities help promote a people centred system

Source Swanbury Penglase Architects 2012

Keys questions, therefore, are as follows: Does the provision of new facilities on the Glenside campus improve the delivery of mental healthcare and drug and alcohol services, including enhanced integration with the broader community? Has the re-development of facilities supported by administrative office space, the Drug

Fig. 4.107 Glenside Campus Redevelopment Australia—Spaces of transition outdoors 4 such as corridors, reception areas and outdoor places are important for hospital design because they foster links with the community (*Source* Swanbury Penglase Architects 2012)

and Alcohol Services South Australia (DASSA) State Office, amenities and an education and research centre been successful in bringing together a variety of land uses on the Glenside campus incorporating the state-of-the-art healthcare facilities? DASSA has the strategic goal of the prevention and management of drug problems across South Australia.

The POE once initiated would involve a two-stage programme with a final report in March 2014. Stage 1 POE of the existing healthcare facilities intends to use questionnaires and workshops to collect and analyse baseline data for the Rehabilitation Services, Shared Activities, and Helen Mayo House and for DASSA and Acute Services. Stage 2 POE of the new healthcare facilities (6 months after occupation) intends to use questionnaires and workshops to collect and analyse data for the Rehabilitation Services, Shared Activities, and Helen Mayo House and for DASSA and Acute Services (Figs. 4.108, 4.109, 4.110).

Lessons from Glenside Campus Redevelopment, Adelaide, Australia

The Master Plan indicates a co-ordinated strategy for re-development involving organisation of the site into 5 Precincts. Key design principles for the integrated sustainability and evidence-based design approach are:

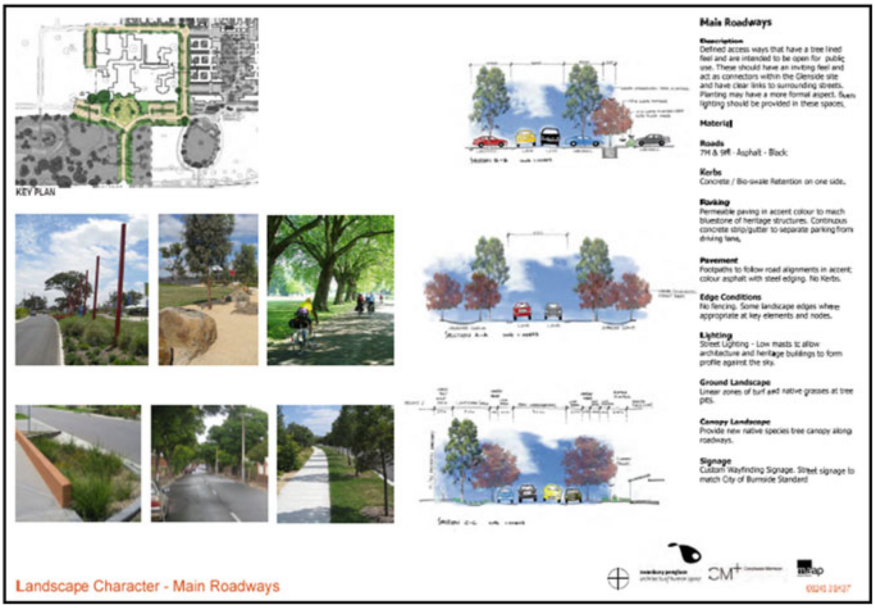

Fig. 4.108 Glenside Campus Redevelopment Australia—Defined access ways are designed to have a tree-lined feel and are intended to be for public use. They are to have an inviting feel and act as connectors within the Glenside Site clearly linking with the surrounding streets. Formal planting and lighting provided in spaces are key design features (*Source* Cundall + Swanbury Penglase Architects 2012)

a. A place of refuge, safety, security and healing.
b. Demystification, destigmatisation, autonomy and integration.
c. High standard of aesthetic design quality and park-like settings.
d. Accommodation of diversity.
e. Ecological sustainability incorporating bio retention and overland swales as well as rain water garden.

Precinct 1 is dedicated to the creation of healthcare facilities covering mental health and substance abuse.

Glenside Campus Re-development is notable because of its aspirations to create a benchmark healthcare facility in Australia that also has appropriate international credentials in terms of evidence-based design coupled with ecological sustainability. Perhaps a major lesson from the Glenside Campus Redevelopment Project is the importance of implementing a rigorous process and governance framework should an organisation be prepared not to go for registration under any of the building environment assessment methods such as Greenstar, BREEAM Healthcare or LEED Healthcare and yet seek to design for sustainability. The increasing dominance of and reliance on these building assessment methods and the availability of few credible alternatives for organisations seeking to design for

Fig. 4.109 Glenside Campus Redevelopment Australia—Helen Mayo House: Communal Areas or 'Spaces of transition' such as corridors and reception areas are important for hospital design because they foster links with the community (*Source* Swanbury Penglase Architects 2012)

sustainability highlight the issue of self-assessment versus verification/validation by others in the development of technical guidance and tools.

Glenside Redevelopment Project correctly acknowledges that the success and realisation of the environmentally sustainable design initiatives addressing ten disciplines of sustainability—built form, indoor environment quality, energy, water, land use and ecology, transport, emissions, materials, management and precinct-wide initiatives; and meeting key result areas targets is largely dependent upon the commitment of the project/design team, the development of the initiatives through the life of the design and also their implementation within the operation of the occupied building. Without this, undertaking the proposed targets may not be achieved. Furthermore, the use of computer simulation on the project to underpin the targets is by its nature predictive with output based on historic weather data and standard assumptions. Consequently, the results of the computer simulations may not deemed to be a guarantee future performance but represent a good and helpful foundation.

Glenside Re-development is important and relevant for this Brief, because it addresses mental illness, a problem affecting the modern society worldwide. In the UK, with one in four of the population suffering with a mental health problem and with poor mental health inextricably linked to physical health while those suffering with mental health problems more at risk to long-term conditions such as cardiovascular disease, cancer and diabetes, the challenge cannot be greater especially at a time of financial restraint, austerity and public spending reviews.

Fig. 4.110 Glenside Campus Redevelopment Australia—Elevations: To overcome the social stigma or de-stigmatise the existing site and its Victorian Asylum references courtyard buildings of a domestic scale arranged around a shared central 'healing garden' which is then accessible to both patients and the public alike are provided (*Source* Swanbury Penglase Architects 2012)

Fig. 4.111 Glenside Campus Redevelopment Australia—Elevations 2: To overcome the social stigma or de-stigmatise the existing site and its Victorian Asylum references courtyard buildings of a domestic scale arranged around a shared central "healing garden" which is then accessible to both patients and the public alike are provided (*Source* Swanbury Penglase Architects 2012)

The situation relating to the rise of mental health problems is similar in other countries in the modern world. For example studies in the US report high rates of mental health disorders including post-traumatic stress disorder, depression, alcohol use disorders among active duty military personnel and veterans of Operation Iraqi Freedom and to a lesser extent Operation Enduring Freedom (Hoge et al. 2004).

With Mental Health contributing to the UK National Health Service costs of £136.4billion in 2009 (compared to £11.4billion in 1948 when the National Health Service was founded) (Office for National Statistics 2012) and the Department of Health's Quality Innovation, Productivity and Prevention (QIPP) targets of transformational programme for £20billion savings by 2015, it seems there is a role for the built environment in aiding recovery from depression, anxiety and other mental health problems if cost savings are to be achieved. It has also been shown that poor mental health lends itself to patients developing mental health issues as a result of living with such disease, while good mental health can be a key preventative factor to developing physical ailment. Crucially, with devastating consequences, stigma and discrimination affects the opportunity for people suffering with mental health problems to live an ordinary life that most other people come to expect. Without undermining a mental health strategy that promotes prevention and early detection + intervention clearly recovery is crucial to the success of the strategy.

National Heart Centre, Singapore

The National Heart Centre represents a competition winning entry by architects Broadway Malyan partnering Ong & Ong. The Centre for the client Singapore Ministry of Health is part of a larger master plan to redevelop the country's General Hospital Outram Campus to create the first sustainable and a rigorous environmental, social and economic focussed hospital in South East Asia.

The Centre brings together cardiac specialists and experts from a multitude of medical and surgical disciplines to meet the growing need for high-quality personalised expert care for an increasing ageing population suffering from heart failure, congenital heart disease, acute coronary syndrome and vascular disease (Figs. 4.112, 4.113, Table 4.26).

The first six patient-centred floors of the hospital accommodate a day surgery, operating theatres, clinics, laboratories, and radiology and retail facilities. The hospital also provides facilities for medical records, research laboratories, staff training and education, a library and administrative offices on the upper part of the building, i.e., 7–10 floors which focus on non-patient areas.

In the Singapore National Heart Centre Project, evidence-based architectural healthcare design is implemented through reference to Departmental Relationships and Clinical Adjacencies, provision of Medicinal Courtyard Gardens which

Fig. 4.112 National Heart Centre, Singapore—3D image of the landmark building + site layout: a ground floor open plaza facilitates social interaction and an ease of movement supported by a further series of semi-public open skygardens providing natural daylight and ventilation, rest and recuperation for clinical staff and visitors alike (*Source* Broadway Malyan Singapore 2012)

acknowledge the healing qualities of natural light, access to vegetation and plants, views of nature, and natural ventilation, improved patient healthcare outcomes.

1. *Departmental Relationships and Clinical Adjacencies* (including improving efficiency and effectiveness of staff): Based on a philosophy of 'Placing People First', the operational layout of the ten-storey hospital has been largely determined by an optimal configuration in which the most relevant departmental relationships and clinical adjacencies minimise travel distances for patients, staff and visitors.

Minimising travel distances for staff confirms the traditional approach to hospital planning going back to the 1960s when Pelletier and Thompson (1960) at Yale identified 14 traffic links that made up 91 % of nursing unit traffic, e.g., location of the nurse station as crucial in maximising efficiency. This produced the Yale University Traffic Index Factors (Figs. 4.113, 4.114).

The National Heart Centre, Singapore features a collection of different healthcare-related and social functions arranged, like a collegiate, around open spaces not dissimilar to the medicinal courtyard gardens of the Middle Ages. These internal and external open spaces are designed to expedite healing via the provision of natural light, natural ventilation and pleasant views of nature/surrounding areas. Plants act as a sponge for carbon emissions, a filter mechanism for noxious pollutants out of the air to reduce incidences of air borne infections and diseases (e.g. asthma). Plants aid the reduction of the heat island effect and

Table 4.26 National Heart Centre, Singapore: Factsheet

National Heart Centre (NHC), Singapore—Factsheet
Project type: A World-Class Specialist Centre of Excellence reflecting the continued evolution and change in cardiology and international clinical practice
Project components: The ten-storey hospital is designed to minimise travel distances for patients. The first six floors house a day surgery, operating theatres, clinics, laboratories, radiology and retail facilities. The upper part of the building (i.e. floors 7–10) focus on patient-free zones, such as facilities for staff training
Type of construction: New Construction
Size: 35,000 m^2 Height: 38.12 m
Cost: £73 m: Cost per Sq m = (73/35,000)
Professional services: Architecture, Landscape Architecture, Interior Design
Project team: Client/Developer—Singapore Ministry of Health, Architect—Broadway Malyan + Ong & Ong Pte Ltd, Medical Planner and Interior Consultant—Broadway Malyan, Quantity Surveyor—Davis Langdon & Seah Singapore Pte Ltd, Structural Engineer—Squire Mech. Pte Ltd.
Evidence-based design features and interventions: Design concept is based on 7 key design considerations: (1) *'Places People First'* which respects the needs of the individual in their everyday working, living, playing and healing life—be they the patient, doctor or visitor. (2) Incorporates open places at the heart of the design that serve the dual function of healing people and healing its surrounding built environment. (3) Establishes the NHC as a world-class facility that sets a global precedent for sustainable heart related healthcare development through a rigorous environmental, social, and economic design. (4) Provides a physical and social connectivity to the urban fabric and the social structure via the open space network. (5) Creates a structure that is flexible and adaptable to change, both internally and externally, and capable of adapting to healthcare technological advancements. (6) Ensures a deliverable sustainable development that uses modern methods of modularisation to facilitate and an ease and speed of construction and 7. Defines a green benchmark for Healthcare design in South East Asia, given the sustainable values, which underpins the design born out of a multi-disciplinary process
Sustainable features: Building & Construction Authority's GREEN MARK INITIATIVES (Green Mark version 3) achieving a Green Mark Score of 92.75 out of 160 Platinum—[PART 1 Energy Efficiency, PART 2 Water Efficiency, PART 3 Environmental Protection, PART 4 Indoor Environmental Quality and PART 5 Other Green Features] The lower score on Renewable Energy is probably explained by the urban location of the Centre. Key features include Daylighting & Views, Energy Efficiency and Adjustable Air conditioning achieving maximum scores 42 out of 42 in the Green Mark Initiatives for the items Building Envelope and Air-conditioning System. A green benchmark for healthcare design in South-east Asia and a global precedent for sustainable heart-related healthcare development through a rigorous environmental, social and economic design. Construction uses a modular method to help expedite the construction phase of the project. Recognising the correlation between the healing properties of natural light and planting, the design concept draws inspiration from the medicinal courtyard gardens of the past monasteries, from whence the term hospital (from the Latin 'hospes') (from Mediaeval Latin *hospitle*, from neuter of Latin *hospitlis*, of a guest, from *hospes*) originates. The skygardens, in their social context, assist in healing society back to good health, whilst in their physical context assist in reducing the built environment's carbon sores. 'The planting acts as a carbon sponge, noxious pollutants filter and heat reducer—an important feature in a city that crams over 4 million people into a 265-sqmile area'. Cost increase of the Platinum Award was estimated to be 4 %

Source Broadway Malyan Singapore 2012

maximising efficiency. This produced the Yale University Traffic Index Factors.

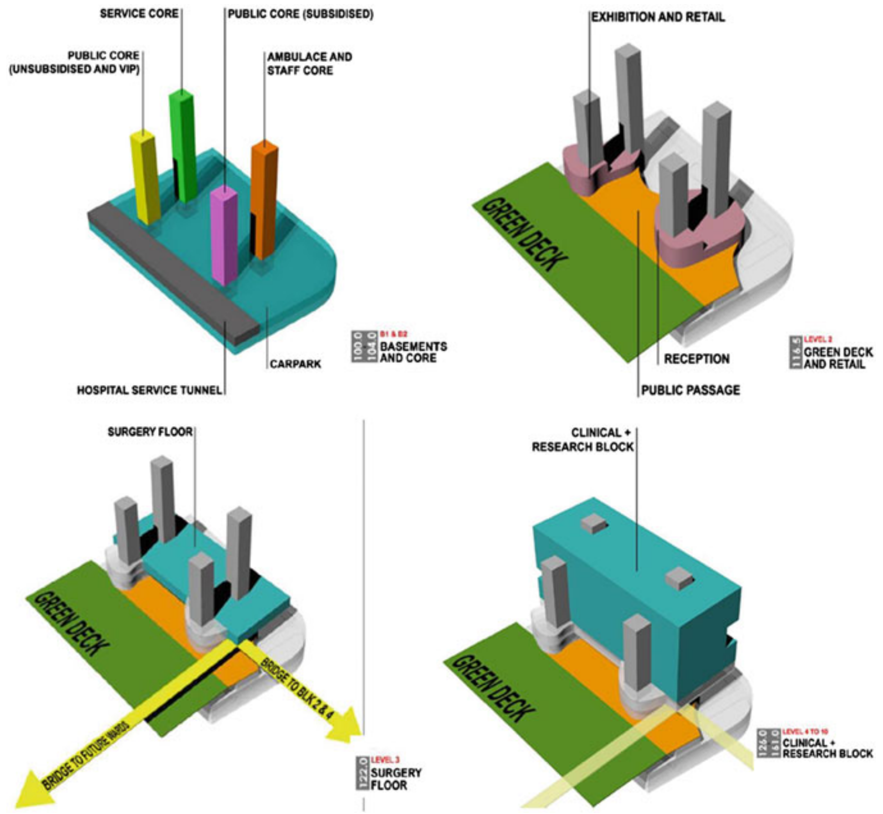

Fig. 4.113 National Heart Centre, Singapore—Design Methodology: Spatial Organisation, departmental relationships and clinical adjacencies—An optimal configuration has the most relevant departmental relationships and clinical adjacencies minimise travel distances for patients, staff and visitors (*Source* Broadway Malyan Singapore 2012)

mitigate the problem of high noise levels due to the increased use of paved surfaces or hard landscaping (Figs. 4.115, 4.116).

The internal open spaces have been maximised to encourage footfall through the building's open spaces creating heightened opportunities for social interaction and increased drive to retail opportunities. The retail therapy from the shopping and moving around serve as important distractions. Provision of clearly understandable circulation routes that facilitate easier navigation and wayfinding through the centre not only improves operational efficiency for staff but also mitigates or alleviates anxiety by patients, staff and visitors as indicated by studies (Ottosson and Grahn 2005; Grahn and Stigsdotter 2003; Passini et al. 2000; Tennessen and Cimprich 1995; Cimprich 1993). This makes for a better staff and patient experience while helping improve satisfaction.

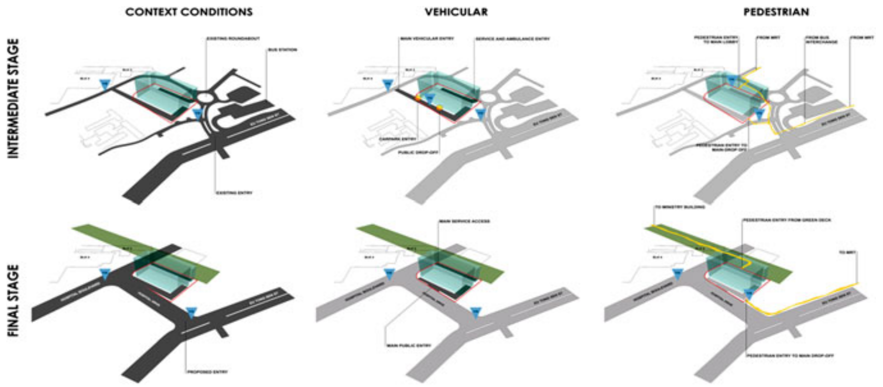

Fig. 4.114 National Heart Centre, Singapore—Vehicular and pedestrian routes (*Source* Broadway Malyan Singapore 2012)

Fig. 4.115 National Heart Centre, Singapore—'Healing Park': studies show the importance of mature trees as having healing qualities and properties (*Source* Broadway Malyan Singapore 2012)

2. *Medicinal Courtyard Gardens*: A key design feature of the hospital is the provision of courtyard gardens that facilitate the interaction of patients, staff and other workers. These spaces, which aim to connect socially all who use the building are fused with natural light and are naturally ventilated to aid the healing process (Nordh et al. 2009; Van den Berg et al. 2007; Sherman et al. 2005; Varni et al. 2004; Taylor et al. 2001, 2002; Beauchemin and Hays 1996; Kaplan and Kaplan 1989; Ulrich 1984) (Fig. 4.115).
3. *Improving Patient Healthcare Outcomes*: As a World Class Healthcare facility at the fore front of latest developments in technology requires that The National Heart Centre Singapore's design achieves appropriate space standards that help improvements on treatment outcome indicators comparable with international benchmarks (such as the Centre for Medicare and Medicare Services and the US Joint Commission International):

- A median length of hospitalisation of 3 days compared with 9 days.
- Re-admission within 30 days of discharge at 12.4 % compared with 22 %.
- In-hospital mortality of 0.93 % compared with 6.7 %.
- 30-day mortality rate of 3.4 % compared with 11.1 %.

Fig. 4.116 National Heart Centre, Singapore—'Sky Gardens' enable patients and staff easy and convenient access to outdoors. Of importance the skygardens, in their social context, assist in healing society back to good health, whilst in their physical context assist in healing the built environment's carbon sores (*Source* Broadway Malyan Singapore 2012)

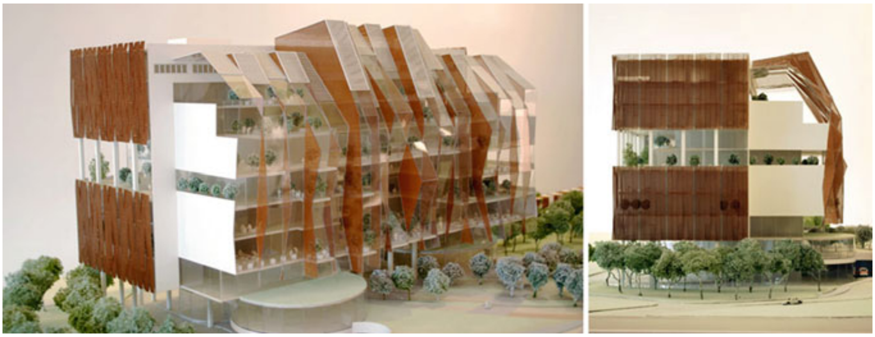

Fig. 4.117 National Heart Centre, Singapore—The hospital has two distinctive façades: the dynamic façade emphasises the public areas as large portions of the skin seem to be peeled back to reveal the inner programmes of the gardens (*Source* Broadway Malyan Singapore 2012)

The new facility will support and enhance the trailblazing performance such as Asia's first successful transapical-transcatheter mitral valve-in-valve implantation for high-risk patients with worn out heart valves carried out on 14 February 2012

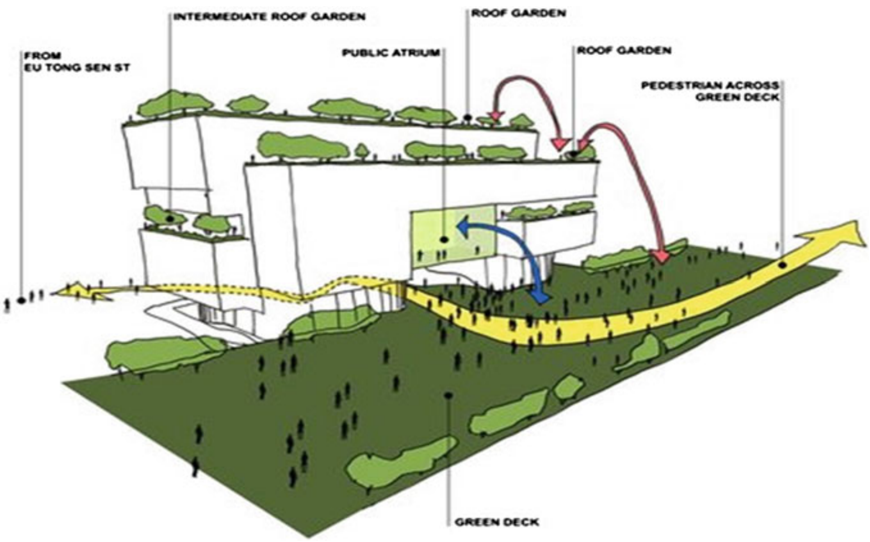

Fig. 4.118 National Heart Centre, Singapore—Sketch (*Source* Broadway Malyan Singapore 2012)

Fig. 4.119 National Heart Centre, Singapore—The less-dynamic Façade (*Source* Broadway Malyan Singapore 2012)

by the multi-disciplinary surgical team led by Dr Soon Jia Lin, Consultant with the Department of Cardiothoracic Surgery. This procedure was first carried out in Canada in 2007 and involves making an incision 6 to 8 cm long on the patient's chest to insert the new valve implant into the heart through a catheter tube. A balloon inside the valve is then inflated to expand the latter, which will stick to the interior walls of the old valve to seal the leak. This minimally invasive method is safer when compared to open heart surgery, where the patient's chest has to be cut open and the heart has to be stopped during a long operation to perform the valve replacement. The predicted mortality rate in such cases is lower at 13.4 % with a 27.8 % predicted risk of prolonged hospital stay if the patient were to have their chest opened up a third time. Also after the procedure, a patient is able to walk again just 5 days later ready to return home within a week to a better quality of life, a marked improvement from 11 days of hospitalisation back in 2005 after the patient's first open heart surgery.

4. *Natural Light*: Recognising the correlation between the healing properties of natural light and plants, the design concept draws inspiration from the medicinal courtyard gardens of the past monasteries, from whence the term hospital (from the Latin 'hospes') originates.

The hospital has two distinctive façades. One façade incorporates the 'official' front entrance which receives patients and looks both sombre and professional reflecting the image of a world-class healthcare Centre. The other façade approached via a piazza contains a second entrance and is portrayed in a more light-hearted way with cladding of raw, unpolished stones and pockets of greenery embedded within the external walls. This hospital's dynamic façade emphasises the public areas as large portions of the skin that seem to be peeled back to reveal the gardens at high level (Figs. 4.117, 4.118, 4.119).

5. *Increasing patient, family and staff satisfaction*: With a design philosophy whose goal is creating a welcoming environment based on understandable circulation and exciting dramatic open spaces, the majority of visitors and patients enter the ten-storey building via a spacious, naturally lit and airy concourse area. The aim of enhancing patient experience means that users arrive into a large and welcoming reception, information and quarantine zone containing retail shops and cafés leading up to decentralised department reception areas and the upper levels of the hospital (Figs. 4.120, 4.121, 4.135, 4.136, 4.137).

The idea of openness and spaciousness is carried throughout the main building as the hall ways enlarge to create more circulation space. These enlarged circulation corridors or passages serve a dual purpose in maximising retail opportunities for users as well as creating spaces that enhance operational effectiveness and efficiency of staff.

Concern with the technical issues of actually delivering and constructing the hospital and with the performance of the main building components saw the adoption of modern modular construction methods to facilitate and to ease the

Fig. 4.120 National Heart Centre, Singapore—Reception area: (*Source* Broadway Malyan Singapore 2012)

speed of construction. The aim was to have the building constructed as quickly and easily as possible under the circumstances of the site and to offer a robust, innovative and yet easily maintainable design solution.

6. *Provision of Spacious and Well-equipped Operating Theatres*: Despite the introduction of same-day ambulatory centres that handle less acute cases, changes in medicine still mean the trend is towards an increasing demand for operating theatres for more complex cases that require a hospital setting and overnight hospital setting. The modern operating room was a vital addition to aseptic technique and essential to the development of invasive surgery (Clemons 2000). Since then the design of the operation rooms and their ancillary spaces has responded to changes in surgical needs and practice

Fig. 4.121 National Heart Centre, Singapore—Waiting areas (*Source* Broadway Malyan Singapore 2012)

evolving from operations being undertaken on hospital wards, in patients' homes and doctors' consulting rooms (Essex-Lopresti 1999). The use of operating theatres has been changing with the increased use of laparoscopic or minimal access surgery, and many procedures previously undertaken there (e.g. endoscopies) now being carried out elsewhere in specialist departments; angioplasty and stent insertion in radiology departments (Essex-Lopresti 1999). In turn, these theatres have been getting larger due to the size and number of equipment stacks (from CT or MRI scanners, surgical robots to sophisticated endoscopic equipment with a common sterile interface for operating lights, table positioning, pumps, shavers, insufflators and electrosurgical equipment) needed to perform the surgery (Figs. 4.122, 4.123, 4.124, 4.125).

Fig. 4.122 National Heart Centre, Singapore—Operating theatres—Integrating advances in medical technology within the operating theatre environment (*Source* Broadway Malyan Singapore 2012)

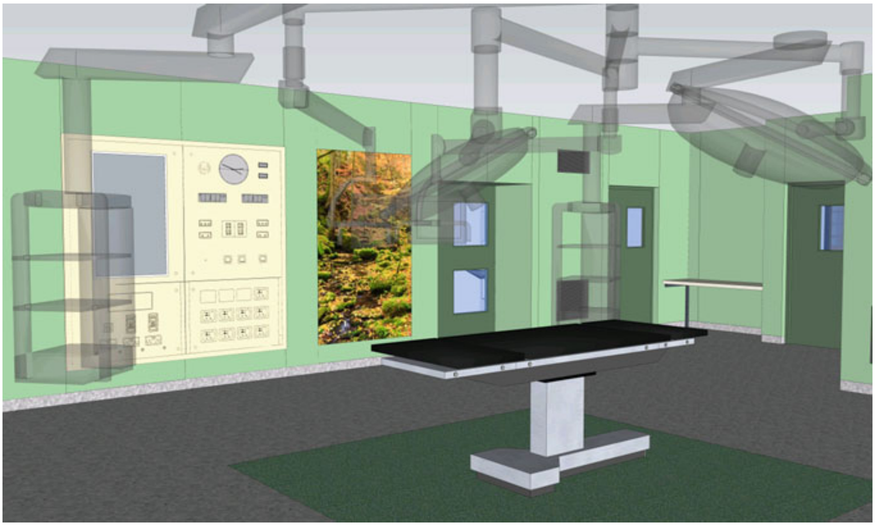

Fig. 4.123 National Heart Centre, Singapore—Operating theatres 2—Integrating advances in medical technology within the operating theatre environment (*Source* Broadway Malyan Singapore 2012)

Fig. 4.124 National Heart Centre, Singapore—Operating theatres 3—Integrating advances in medical technology within the operating theatre environment in a way that supports staff while enhancing the patient's healing process is a key design priority for any new solutions: high definition solutions include seamless connection of cameras, video switching, audio-visual infrastructure, media storage and high definition video conferencing (*Source* Broadway Malyan Singapore 2012)

Baillie (2012) reports how typically technological developments and requirements for minimal access surgery have resulted in laparoscopic theatres that offer:

- An equipment mounting solution that keeps all laparoscopic surgical equipment off the ground, and enables it to be articulated around the operating zone, eliminating cable trail.
- High-definition cameras that relay crystal clear images via laparoscopic surgery instrument's camera to surgical viewing monitors.
- Boom-mounted high-definition surgical viewing monitors, positioned around the sterile field for optimum efficiency and the best operating position.
- A dedicated surgeon's screen operable even if power fails; a second monitor for the assistant surgeon and a wall-mounted monitor for circulating nurses.
- Digital image transmission to remote sites for education (professional development courses, medical lectures and knowledge sharing), operating skills practice and training, tele-monitoring, medical record capture and archiving.

Systems that provide still image capture, video recording, report writing and auditing of the reports, images and videos also allow registered users with secure access to subsequently view and evaluate the images captured during surgery. For example, one pioneering operation procedure for supine laparoscopic and thoracoscopic oesophagectomy for oesophageal cancer was able to be broadcast to 600 surgeons attending a high profile seminar.

- Connections to the hospital network and teaching locations.
- Fully adjustable coloured room lighting as part of a comfortable working environment that enhances compliance with guidance such as Health Technical Memorandum (HTM) 03-01 for noise levels at NR45 and performance of the laminar air flow installation as indicated by the non-entrainment test.
- Studio-quality loudspeakers with docking stations for MP3 players so that music can be played in the operating theatre.

The operating theatres at the National Heart Centre are spacious in area to accommodate the growth of cart-mounted specialist equipment and monitors with adequate space around the equipment for staff to move around. To be used efficiently and effectively by the surgical team, instruments, supplies and equipment must be within the ‘reach zone’ immediately adjacent to the operating room table. Items out with the ‘space within reach’ must be remotely operated or must be moved before being put into use. However, there are also consequences of placing equipment on carts; notably, this places all of the equipment at roughly the same working plane across the room, and the volume of each cart space around the cart are then typically unusable for other purposes. Large and larger operating rooms are not necessarily the solution as these then trigger other conditions, for example, all the utilities and other items mounted on walls are then further away from the operating table resulting in poor, low-density use of the space within reach around the operating room table that fosters inefficiency and functionality (Figs. 4.122, 4.123, 4.124, 4.125).

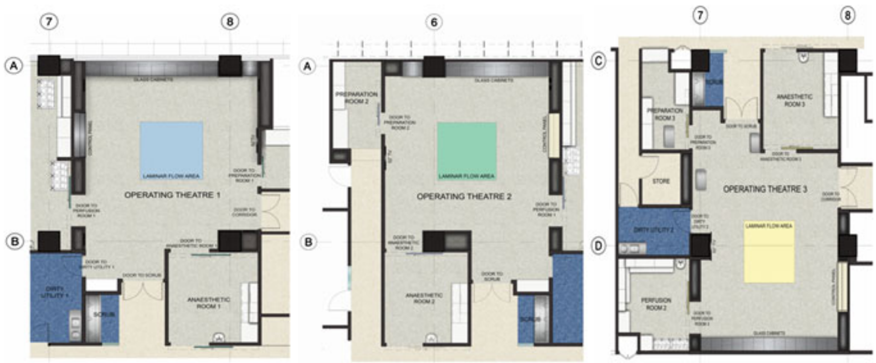

Fig. 4.125 National Heart Centre, Singapore—Operating theatres 4: floor layout plans for the 3 theatres—Integrating advances in medical technology within the operating theatre environment (*Source* Broadway Malyan Singapore 2012)

Designed as ‘hybrid’, ‘smart’ efficient operating theatres with ceiling-mounted booms or pendants to hold key surgical, anaesthesia and other specialised equipment and monitors to optimise ‘reach zone’ around the operating table the theatres in the National Heart Centre Project allow for both surgical procedures and non-invasive interventions. The patient is scanned and operated on the same operating table, thereby speeding throughput and improving efficiency and precision, since there is no need to transfer or move the individual to a separate imaging suite, for example, in brain surgery this maximises the chances of surgeons removing every trace of tumour while the patient is in theatre, guided by detailed images taken during the surgical operations. Optimising the ‘reach zone’ and versatility around the operating table includes delivering maximum illumination level at the coolest temperature possible while minimising the footprints of the lights, providing an appropriate ventilation (for example via a suitable laminar air flow system) to maintain a comfortable working environment that minimises risk of infections as well as making considerations of key factors (room height, patient/table positions, line-of-sight to monitors for multiple surgical positions, use of, and access to ancillary equipment and positioning of scrub staff, surgeon and instrument trolley).

Careful planning that includes 3D modelling of operating rooms (such as ‘Berchtold by Design’ 3D modelling tool) and designing the theatre in conjunction with end-users not only ensures that the surgical team’s requirements are addressed and anticipated but also builds on the team’s experiences (Fig. 4.126).

7. *Accommodating flexibility and the capacity to adapt to future demands*: The design of a flexible hospital needs to incorporate modular units and standardisation in order to provide the capacity to grow and change to meet the future medical needs, for example overcrowding due to unanticipated demands (Carthey et al. 2011). Manifestations of overcrowding emergency departments include ‘boarding’ of patients, increased risk of medical errors, ambulance diversion, threat to disaster preparedness and eroding reliability of the emergency care system (Trzeciak and Rivers 2003). Studies also report that the average waiting time for an inpatient acute or critical care bed in typical US Emergency Departments is more than 3 h, which nearly doubles to 5.8 h in hospitals that consistently have emergency overcrowding (McCarthy 2011; Trzeciak and Rivers 2003). Emergency Departments must therefore be redesigned to meet patients’ needs more effectively and efficiently. Otherwise, when Emergency Departments operate less efficiently, more deaths and hospital admissions occur in discharged patients. The spatial flexibility is enhanced and achieved by over sizing of the inpatient care, critical care spaces including operating theatres with above the recommended clearances.

In the National Heart Centre Project, horizontal and vertical expansion incorporate planning and design that includes provision of ‘shell’ space and additional space for expansion, strengthening of the structure (floors, ceilings, columns and foundations) or structural elements, flexible modular spaces, ceilings and ceiling heights that accommodate future ceiling-mounted angiography equipment and air-handling units, façade openings that allow for removal of old equipment and

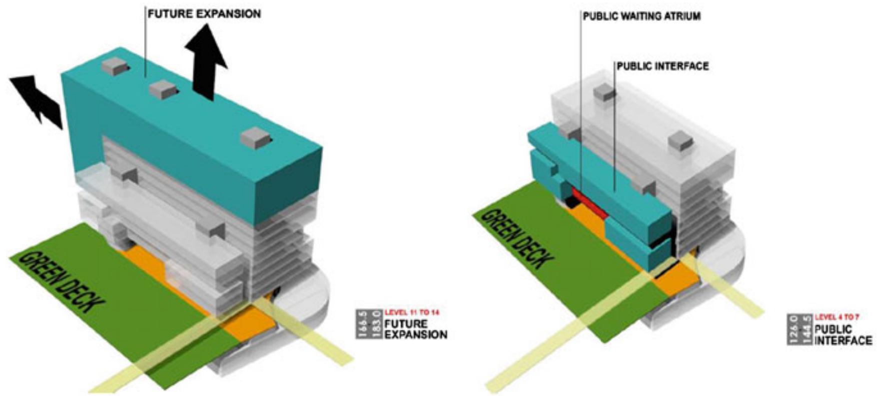

Fig. 4.126 National Heart Centre, Singapore—Accommodating flexibility and ability to adapt to future demands: both horizontal and vertical expansion incorporate planning and design that includes additional space for expansion, strengthening of the structure or structural elements, flexible modular spaces, ceiling heights that accommodate future air-handling units, façade openings that allow for removal of old equipment and delivery of new equipment and catwalk systems for servicing and maintenance (*Source* Broadway Malyan Singapore 2012)

delivery of new equipment and catwalk systems for servicing and maintenance. The design incorporates 'soft spaces' which can in future be adapted and used as expansion areas for the 'hard spaces' such as the imaging department (Figs. 4.126, 4.127, 4.134).

8. *Accommodating Changing Medical Technological Demands*: Medical technology (notably MRI Units, CT Scanners, Ventilators, Life-support Machines, Drug-eluting Stents, Syringe-drivers, Blood Glucose Testing Kits and other devices or equipment) now plays a much more pivotal role in the diagnosis, early detection, prevention, monitoring and treatment of heart diseases. Remaining competitive healthcare facilities must continually change in order to support new procedures and technologies and to meet staff and patient demands. Accommodating medical equipment entails clear specifications in terms of power consumption or energy use, special circuitry, different medical gases, data and video communications, spatial requirements and logistics for the kit's installation, servicing, maintenance and replacement as well as compliance with health and safety regulations, for example, for robotic intra-operative radiation therapy lead shielding for future MRI magnets or recommendations such as the airflow rate in an operating room of 20-25 air changes per hour for ceiling heights between 2.74 m (9 ft) and 3.66 m (12 ft) (Memarzadeh and Jiang 2004). Consideration of the operation of the medical equipment is essential to meet targets to reduce energy use and achieve sustainability as well as to minimise service disruption and down time and thereby loss in revenue. Supply and operation of medical equipment is one of the key drivers of healthcare spending and needs to be addressed in order to reduce costs.

Advances in the technology have seen a rapid increase of minimal access surgery or minimally invasive surgical interventions and procedures that have been largely responsible for reducing length of hospital stays, rates of re-hospitalisation and recovery times in turn improving quality of life and increasing the life expectancy. The development of minimal access techniques represents the most significant change in surgical practice since the introduction of aseptic technique or safe anaesthesia (Jaffray 2005). Specifically, the entire cardiovascular tree is now more amenable to percutaneous interventions facilitated by imaging technologies such as the electron-beam tomography scanner. Yet another important factor is the drive to reduce costs associated with invasive procedures such as surgery-based protocols and risks of hospital associated infections with the major source of contamination being the operating team itself, for example masks are not always worn in the theatre during an operation except by those at the operating table.

The National Heart Centre Project embraces and deploys the latest technologies as part of a consistent strategy of developing the national Centre of Excellence, which is comparable with other centres in the world. The challenge for the centre is keeping abreast with the innovations or changes in the form of these new technologies occurring daily in hospitals worldwide from mobile wireless tools, high-speed Internet connections and networking hardware to enhance communications, sophisticated simulation dummies to help train medical personnel, interactive television and telemedicine. This means considerations of (a) medical devices that deliver treatment such as those implanted during surgical procedures; (b) technologies that provide greater independence or autonomy to patients; and (c) diagnostic devices or tests used to detect or monitor medical conditions.

9. *Design for Sustainability*: This is particularly relevant for a hospital in a highly urbanised location in a country where very little primary rainforest now remains and where the built environment has to serve and address demands from high population densities. This forms part of the overall strategies to limit urban sprawl and enhance spatial development and land management that

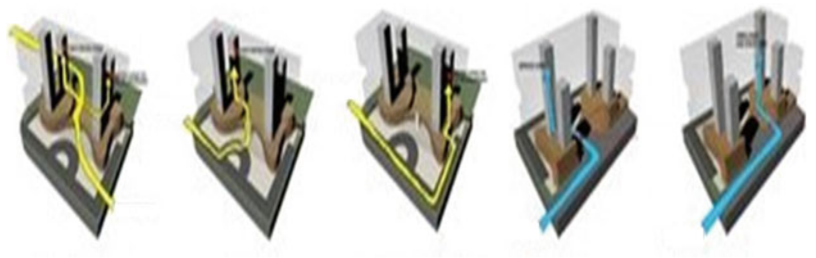

Fig. 4.127 National Heart Centre, Singapore—Modelling (*Source* Broadway Malyan Singapore 2012)

Fig. 4.128 National Heart Centre, Singapore—Park landscaping (*Source* Broadway Malyan Singapore 2012)

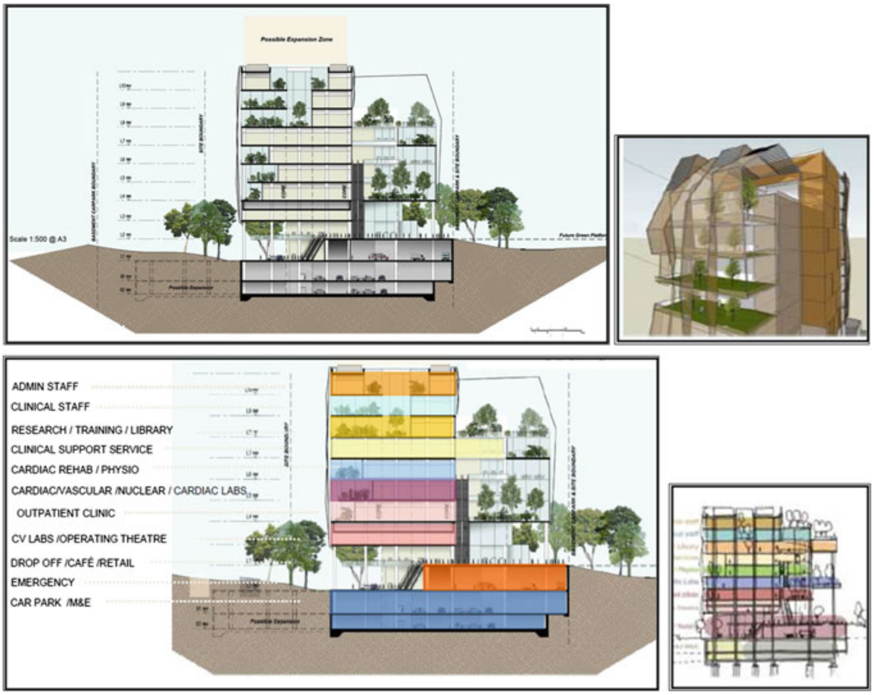

Fig. 4.129 National Heart Centre, Singapore—Typical sections (*Source* Broadway Malyan Singapore 2012)

includes improved integration of land use and transport planning, rehabilitation of brownfield sites, redevelopment of industrial sites and the regeneration of run-down areas. The approach also includes site coverage to ensure that the built environment is not inappropriately overloaded with building mass, for example exceeding over 80 % (i.e. total area of the site divided by the ground floor area of the building). The urban environment (buildings, cities and infrastructure) represents one of the important contributors to climate change and also holds the key to sustainable building and a more sustainable way of life (Figs. 4.128, 4.129).

In the Singapore, National Heart Centre Project sustainability is implemented through strategy that aims to address the reduction of CO_2 emissions, adopting a compact building form, which optimises the provision of natural light and natural ventilation rather than artificial light and mechanical ventilation as a way of reducing energy consumption.

Consequently, the building form, massing and siting have been designed to have two distinctive visually striking façades ('dynamic' vs. 'sombre' features), which use different materials and building components/elements but aim to take advantage of their orientation (Fig. 4.119).

In this case, materials, colours and textures have also been selected to articulate and enrich the building's form and enhance its enjoyment.

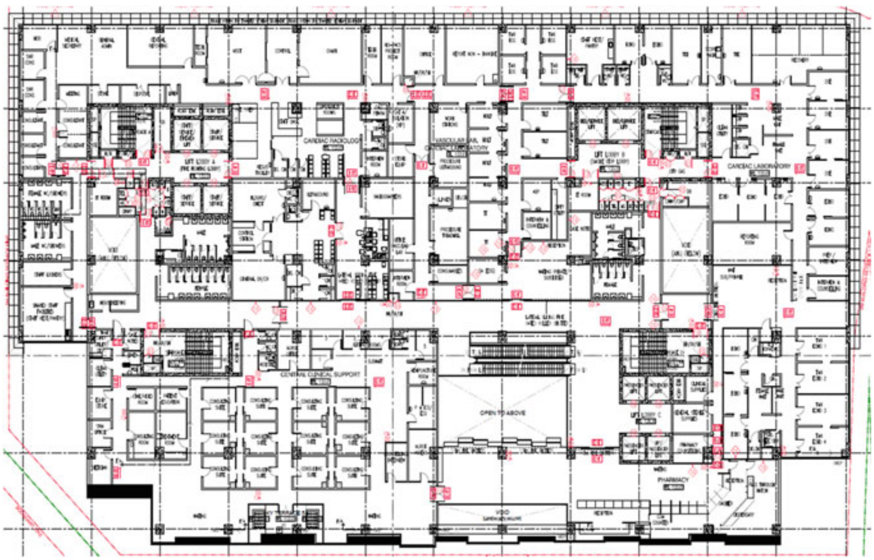

Fig. 4.130 National Heart Centre, Singapore—5th storey floor layout plan: level 5—Tree house (Waiting Area for Private Clinics and Pharmacy), Radiology, + Cardiac Laboratory (*Source* Broadway Malyan Singapore 2012)

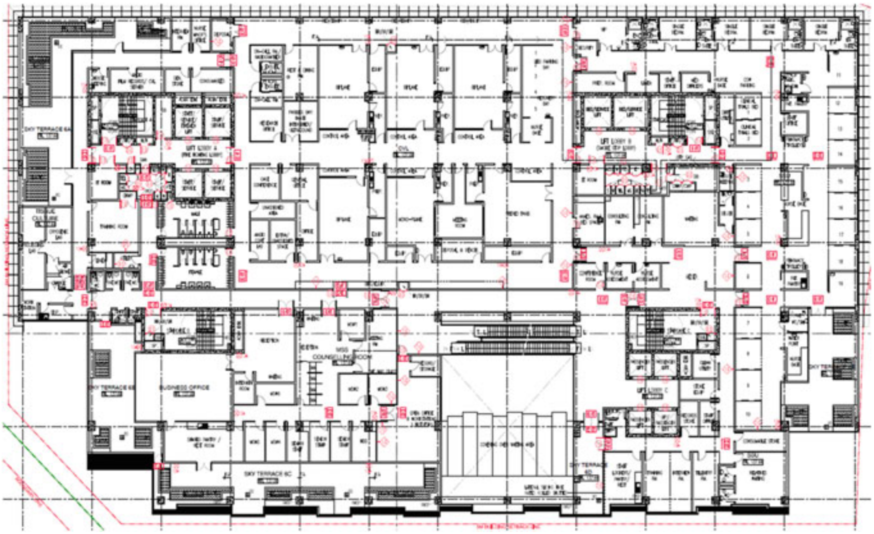

Fig. 4.131 National Heart Centre, Singapore—6th Storey floor layout plan: level 6—Cath Laboratories, Short Stay Unit with Nurse Base and Tissue Culture Laboratory. Location of the 'Sky Gardens' (*Source* Broadway Malyan Singapore 2012)

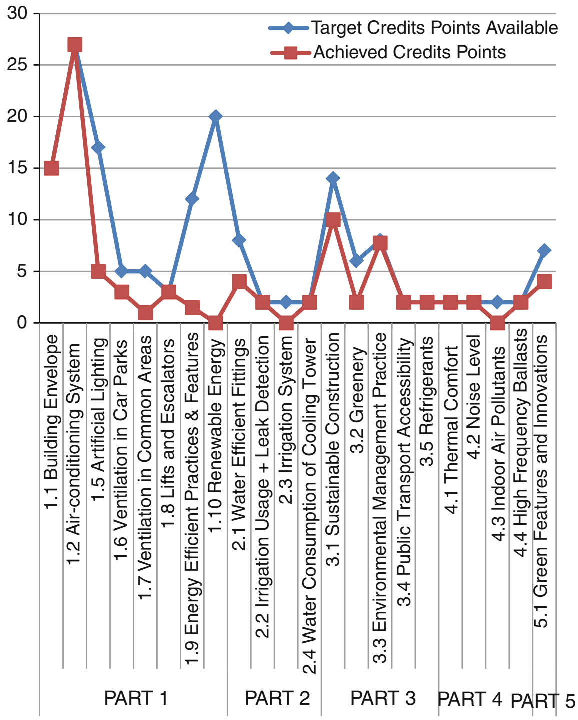

Fig. 4.132 National Heart Centre, Singapore—GREEN MARK SCORE of 92.75 out of 160 Platinum—[PART 1 Energy Efficiency, PART 2 Water efficiency, PART 3 environmental protection, PART 4 Indoor environmental quality and PART 5 Other green features]. The lower score on renewable energy is explained by the urban location of the centre and little provision for renewable energy. Also Singapore buildings are predominantly air-conditioned but are encouraged to have a provision of natural ventilation particularly in residential buildings and in common areas (*Source* Broadway Malyan Singapore 2012)

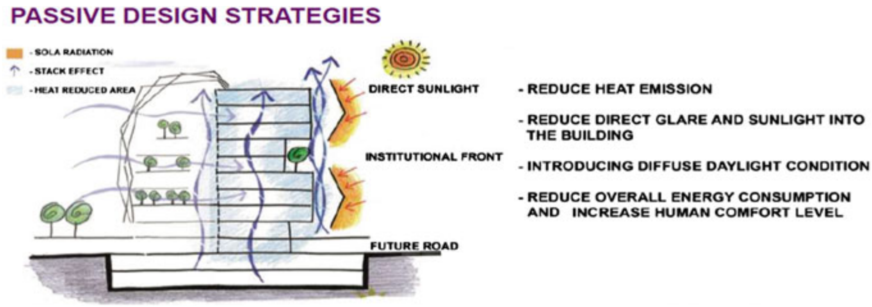

Fig. 4.133 National Heart Centre, Singapore—Passive design strategies (*Source* Broadway Malyan Singapore 2012)

The National Heart Centre Singapore achieved maximum scores 42 out of 42 in the Building and Construction Authority's Green Mark Initiatives for the items Building Envelope and Air-conditioning System somehow compensating for lack of scores on the item on Renewable Energy (Figs. 4.126, 4.132, 4.133, 4.134, Table 4.27). All this may impact on energy use and running costs during the post-project stage or post-occupancy after the completion of the project. The Platinum Award indicates the following predictions:

ENERGY EFFICIENCY: Annual energy savings of 6,500,000 kwh, a 30 % reduction compared with a normal building, with a cost savings of $1.3 million per year.

WATER EFFICIENCY: Annual water savings of 12,000 m^3, a cut of 55 %, equivalent of 5 Olympic-sized pools.

ENVIRONMENTAL PROTECTION: Annual carbon dioxide emission reduction of 3,000 t, equivalent of 525 cars' annual carbon dioxide emission.

The National Heart Centre, Singapore has registered with BRE and has the goal of achieving BREEAM 'Excellent' rating (>70 %) and certification. This means the goal of earning all the necessary mandatory credits for this classification under the categories for management, health and well-being, energy, land use and ecology and waste.

Lessons from National Heart Centre, Singapore

A major lesson from the design of the National Heart Centre, Singapore is the aim to serve the dual function of healing people and the surrounding built environment, while providing a wider physical and social connectivity to the urban fabric of Singapore via its open space network and social structure.

The concept is indicated by seven design considerations:

1. *Places People First* which respects the needs of the individual in their everyday working, living, playing and healing life—be they the patient, doctor or visitor.

Table 4.27 National Heart Centre, Singapore—Green mark initiatives

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
PART 1—Energy efficiency Applicable to Air-conditioning Building Areas (with aggregate air-conditioned areas >500 m^2) CATEGORY SCORE Target Credit Points Available = 70 Achieved = 50	1.1 *Building Envelope—ETTV*: Enhance the overall thermal performance of the building envelope to minimise heat gain thus reducing the overall cooling requirement *Baseline*: Maximum Permissible ETTV = 50 W/m^2; *Prerequisite Requirements*: PLATINUM < 40 W/m^2 – 2 Credit Points for every reduction of 1 W/m^2 in ETTV from baseline [15 Credit Points Available] – Credit Points awarded = 100−2(ETTV) where ETTV ≤ 50 W/m^2	Target Points = 15 Achieved = 15 maximum Credit Points scored under both conditions
	1.2 *Air-conditioning system*: Encourage the use of better efficient air-conditioned equipment to minimise energy consumption. The systems to be considered are: (a) 1. *Air-conditioning Plant* (Chiller, Chilled-Water Pump, Condenser Water Pump and Cooling Tower); (a) 2. *Air Distribution System* (Air-Handling System-AHUs and Fan Coil Units-FCUs) *Baseline*: Minimum efficiency requirement of the air-conditioning system stated in SS 530 & SS CP 13. *Pre-requisite Requirements*: PLATINUM < 0.65 kW/Ton (Incremental cost $200,000 to achieve < 0.65 kW/Ton) – 1.45 Credit Points for every percentage improvement in thelow 1,000 ppm.e efficiency of Chiller, Chilled-Water Pump and Condenser Water Pump [20 Credit Points Available] – Credit Point awarded = 1.45 x (% Improvement) NOTE 1. For buildings using district cooling system, there is no need to compute the plant efficiency under item (a) 1. The points obtained will be pro-rated based on the air distribution system efficiency under item (a) 2.	(a) 1. Target Points = 20 Achieved = 20 maximum Credit Points scored under both conditions (a) 2. Target Points = 5 Achieved maximum points scored under both conditions
	OR (b) Unitary Air conditioners/Condensing Units (Single-Split Unit, Multi-Split Unit and Variable Refrigerant Volume (VRV) System – 1.5 Credit Points for every percentage (average) improvement in the efficiency of all unitary air conditioners/condensing units – Credit point awarded = 1.5 × (% improvement) NOTE 2. Where there is a combination of centralised air-conditioning system with unitary air-conditioned system the computation for the points awarded will only be based on the air-conditioning system with a larger aggregate capacity	Target Points = 25 Achieved = Not applicable

(continued)

Table 4.27 (continued)

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
	(c) Sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain the concentration of carbon dioxide below 1,000 ppm	Target Points = 2 Achieved = 2
	1.5 *Artificial Lighting*: Encourage the use of better efficient lighting to minimise energy consumption from lighting usage while maintaining proper lighting level. *Baseline*: Maximum lighting power budget stated in SS 530. *Baseline* = Maximum lighting power budget stated in SS 530. The use of halogen light fittings to be minimised and medical lighting to be excluded in the calculation – 0.5 Credit Points for every percentage improvement in lighting power budget – Credit Points awarded = 0.5 × (% improvement)	Target Points (incl. Tenant lighting Provision) = 12 Achieved = 5 Target Points (Excl. Tenant lighting) = 5 Achieved = 0
	1.6 *Ventilation in Car Parks*: Encourage the use of energy-efficient design and control of ventilation systems in Car Parks. Credit Points awarded based on the mode of Mechanical Ventilation provided. (a) Car Parks designed with Natural Ventilation: Credit Points = 5 Points (b) CO sensors are used to regulate the demand for Mechanical Ventilation (MV) Ductless Mechanical Ventilation with CO sensors is used – Credit Points awarded for Fume Extract = 4 Points – Credit Points awarded for Mechanical Ventilation with or without supply = 3 Points NOTE 4 Where there is a combination of different ventilation mode adopted for Car Park design the points obtained under this item will be pro-rated accordingly	Target Points = 5 Achieved = 3
	1.7 *Ventilation in Common Areas*: Encourage the use of energy-efficient design and control f ventilation systems in the following areas: (a) Toilets, (b) Staircases, (c) Corridors, (d) Lift Lobbies and (e) Atriums. Extend of coverage: At least 90 % of each applicable area – Credit Points awarded based on the mode of ventilation provided. 1.5 Credit points for each area with Natural Ventilation and 0.5 Credit Points for each area with Mechanical Ventilation	Target Points = 5 Achieved = 1 (Toilet s M Ventilation 0.5 + Staircases Mechanical Ventilation 0.5)
	1.8 *Lifts and Escalators*: Encourage the use of energy-efficient lifts and escalators. Extent of Coverage: All lifts and/or escalators. In accordance with good and common practice for all (a) Lifts with the following energy-efficient features: (1) AC variable voltage and variable frequency (VVVF) motor drive or equivalent (2) Sleep mode features or equivalent (b) Escalators with energy-efficient features such as motion sensors	(a) Target Points = 1 Achieved = 1. (a)1 Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 1

(continued)

Table 4.27 (continued)

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
	1.9 *Energy-Efficient Practices & Features*: Encourage the use of energy-efficient practices and features that are innovative and/or have positive environmental impact. (a) Computation of Energy Consumption based on design load in the form of energy efficiency Index (EEI) calculated from energy modelling. (b) Use of energy features e.g., Heat Recovery Systems, Motion sensors for staircase half landing, Ductless Fan for basement ventilation + Sun pipes – 3 Credit Points for every 1 % energy saving over the total building energy consumption Important features for PLATINUM Project: (1) Heat recovery for Operating Theatres, (2) Photo sensors for perimeter zones with the availability of daylight, (3) Motion sensors (staircases half-landing, toilets, stores, meeting rooms), (4) Ductless fan for basements and (5) Final figures to be established from energy modelling	(a) Target Point = 1 Achieved = 1 (b) Target Points = 11 Achieved = 0.5
	1.10 *Renewable Energy*: Encourage the application of renewable energy sources in buildings – (Bonus Credit Points) 5 points for every 1 % replacement of electricity (based on the total electricity consumption including tenant's usage) by renewable energy OR 3 Points for every 1 % Replacement of Electricity	Target Points = 20 Achieved = 0
PART 2—Water efficiency Category score Target Points Available = 14 Achieved = 8	2.1 *Water Efficient Fittings*: Encourage the use of water efficient fittings covered under the *Water Efficient Labelling Scheme* (WELS) —'Good' Weightage = 4, 'Very Good' Weightage = 6 and 'Excellent Weightage = 8. RECOMMENDATIONS under Water Efficient Building (WEB) is 'Very Good' for Shower taps, Basin + Sink taps; WC no rating but target 4.5 l/flush and 'Excellent' for Urinals. Medical water fittings to be excluded in tabulations – Credits Points awarded based on the number and water efficiency rating of the fitting type used	Target Points = 8 Achieved = 4
	2.2 *Water usage and leak detection*: Promote the use of sub-metering and leak detection system for better control and monitoring. (a) Provision of sub-meters for major water uses which includes irrigation, cooling tower and tenants' usage. b) Linking all sub-meters to the Building Management System (BMS) for leak detection	(a) Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 1
	2.3 *Irrigation System*: Provision of suitable systems that utilise rainwater or recycled water for landscape irrigation to reduce portable water consumption. (a) Use of non-portable water including rainwater for landscape irrigation. (b) Use of water efficient irrigation system. Extent of coverage: At least 50 % of the landscape areas are to be served by the system	(a) Target Points = 1 Achieved = 0 (b) Target Points = 1 Achieved = 0

(continued)

Table 4.27 (continued)

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
	2.4 *Water Consumption of Cooling Tower*: Reduce portable water use for cooling purpose. (a) Use of cooling water treatment system that can achieve 6 or better cycles of concentration at acceptable water quality. [To Target 7 cycles and above] (b) Use if NEWater or on-site and recycled water from approved sources. [Based on input from M&E]	(a) Target Points = 1 Achieved = 0 (b) Target Points = 1 Achieved = 0
PART 3—Environmental protection Category score Target Points Available = 14 Achieved = 8	3.1 *Sustainable Construction*: Encourage the adoption of building designs construction practices and materials that are environmentally friendly and sustainable. (a) More efficient concrete usage for building components. 0.1 Point for every percentage reduction in the prescribed Concrete Usage Index (CUI) Limit for the respective building Categories (based on input from C&S). (b) Conservation of existing building structure Applicable to existing structural elements or building envelope Extent of Coverage: Conserve at least 50 % of the existing structural elements or building envelope (by area) (not achievable). (c) Use of sustainable materials and products in building construction such as 1. Environmental friendly products that are certified under the Singapore Green Labelling Scheme; 2. Products with at least 30 % recycled content by weight or volume NOTE 5 For products that are certified by SGLS and with at least 30 % recycled contents, Points can only be awarded either from item (c)1 or (c) 2	(a)Target Points = 4 Achieved = 2 (b) Target Points = 2 Achieved = 0 (c) Target Points = 4 Achieved = 4
	3.2 *Greenery*: Encourage greater use of greenery, restoration of trees to reduce heat island effect. (a) Greenery provision (GnP) is calculated by considering the 3D volume covered by plants using the following Green Area Index (GAI) Grass GAI = 1, Shrubs GAI = 3, Palms Trees GAI = 4 and Trees GAI = 6. [GnP = 0.5 to <1: 1 Point; GnP = 1–1.5-2 Points, GnP = 1.5 to <3–3 Points, GnP ≥ 3–4 Points. (Based on inputs from Landscape)(b) Restoration of trees on site, conserving or relocating of existing trees on site (Not achievable within the building boundary), c) Use of compost recycled from horticulture waste (Landscape to be incorporated within the Tender documents)	(a) Target Points = 4 Achieved = 1 (b) Target Points = 1 Achieved = 0 (c) Target Points = 1 Achieved = 1

(continued)

Table 4.27 (continued)

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
	3.3 *Environmental Management Practice*: Encourage the adoption of environmentally friendly practices during construction and building operation. (a) Implement environmental friendly programmes including monitoring and setting targets to minimise energy use, water use and construction waste. (b) Building quality assessed under the Construction Quality Assessment System (CONQUAS). (c) Developer, main builder, M&E Consultant + Architect are to be ISO 14,000 certified. (0.25 Point for each Firm), (d) Project Team comprises of Certified Green Mark Manager (GMM) and/or one Certified Green Mark Professional GMP) (e) Provision of building User's Guide including details of the environmental friendly facilities and features within the building and their uses in achieving the intended environmental performance during construction. (1 Point for GMW 2 Points for GMP) and (f) Provision of facilities or recycling bins for collection and storage of different recyclable waste such as paper, glass and plastics	(a) Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 1 (c) Target Points = 1 Achieved 0.75 (d) Target Points = 3 Achieved = 3 e) Target Points = 1 Achieved = 1
	3.4 *Public Transport Accessibility*: Promote the use of public transport or bicycles to reduce pollution from individual car use within the following: (a) Good Access to the nearest MRT/LRT or Bus stops (b) Adequate Bicycle Parking Lots (To provide 15–20 numbers of bicycle parking lots)	(a) Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 1
	3.5 *Refrigerants*: Reduce the potential damage to the ozone layer and the increase in global warming through the release of ozone depleting substances and greenhouse gases. (a) Refrigerants with ozone depletion potential (OPD) of zero or with global warming potential (GWP) of less than 100 (Good and common design). (b) Use of refrigerant leak detection system at critical areas of Plant Rooms containing Chillers and other Equipment with refrigerants (Good and common design)	(a) Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 1
PART 4—Indoor environmental quality Category score Target points Available = 8 Achieved = 7	4.1 *Thermal Comfort*: Air-conditioning is designed to allow for cooling load variations due to fluctuations in ambient temperature to ensure consistent indoor conditions for thermal comfort. Indoor temperature between 22.5 to 25.5^0 C Relative Humidity <70 %—2 Credits	Target Points = 2 Achieved Credit Points = 2
	4.2 *Noise Level*: Occupied spaces in buildings are designed with good ambient sound levels as recommended in SS CP 13 –2 Credit Points	Target Points = 2 Achieved Credit Points = 2
	4.3 Indoor Air Pollutants: Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment (a) Use of low Volatile Organic Compounds (VOC) paints certified under the Singapore Green Labelling Scheme (SGLS). [Recommended for good IAQ –additio$74,000] (b) Use Adhesives certified he Singapore Green Labelling Scheme (SGLS) for composite wood products. Tall order to score as the requirements to cover at least 90 % of all applicable composite wood products (assumed worse case condition), point not achievable. Recommended to target for adhesives in construction works to provide good indoor air quality (additional $20,500)	(a) Target Points = 1 Achieved = 1 (b) Target Points = 1 Achieved = 0

(continued)

Table 4.27 (continued)

National Heart Centre, Singapore—Green mark initiatives

Category	Description + credits	Target/achieved
	4.4 *High-Frequency Ballasts*: Improve workplace lighting quality by avoiding low-frequency flicker associated with fluorescent lighting with the use of high-frequency ballasts in the fluorescent ballasts in the fluorescent luminaires. Extent of Coverage: At least 90 % of all applicable areas that are served by fluorescent luminaires	Target Points = 2 Achieved Credit Points = 2
PART 5—Other Green Features Category score Target points Available = 7 Achieved = 4	5.1 *Green Features and Innovations*: Encourage the use of other green features which are innovative and/or have positive environmental impact. Examples: Pneumatic Waste Collection System, Rainwater Harvesting, Dual Chute System, Self-Cleaning Façade, Infiltration Trenches and Integrated Storm Water Retention/Treatment into Landscaping. 2 Credit Points for high impact item; 1 Credit Point for medium impact item and 0.5 for low impact item. [GREEN FEATURES 0.5 Credit Points for using membrane filtration system to recycle water during construction; 0.5 Points for using UVC emitters in all AHU; 1 Point for Heat balance/to install permanent measuring instruments for monitoring Plant efficiency –Recommend to add-into ensure reliable BMS reading for A/CX equipments. Not for point scoring purpose, however, will liaise with BCA to score (add-on $23,000); 1 Point for charging facilities for Electric Vehicles (add-on $11,000; 0.5 Point for providing Car Park Guidance System (to be considered) 9Add—on $200,000). OPTIONAL ITEMS: 0.5 Points compost recycled bins (5 no). OTHER GREEN Initiatives: Recycling of ext bricks and materials (Score to be discussed with BCA)	Target Points = 7 Achieved = 4
Green mark overall score Gold^{PLUS} 85 to <90 Platinum >90		92.75 0ut of 160

Source Broadway Malyan Singapore 2012

2. Incorporates open places at the heart of the design that serve the dual function of healing people and healing its surrounding built environment.
3. Establishes the National Health Centre as a world-class facility that sets a global precedent for sustainable heart-related healthcare development through a rigorous environmental, social and economic design.
4. Provides a physical and social connectivity to the urban fabric and the social structure via the open space network.
5. Creates a structure that is flexible and adaptable to change, both internally and externally, and capable of adapting to healthcare technological advancements.
6. Ensures a deliverable sustainable development that uses modern methods of modularisation to facilitate and an ease and speed of construction
7. Defines a green benchmark for Healthcare design in South East Asia, given the sustainable values, which underpins the design that is born out of a multi-disciplinary process.

Improved quality and safety, innovation and utilisation of informed practices and guidelines determine the success or failure of the National Heart Centre. The hospital is a response to the need for innovative and specialist healthcare facilities for the diagnosis, examination and treatment of Singapore's population suffering from various heart conditions.

The building uses modern modular construction methods to facilitate and ease the speed of construction. Standardisation is not good in its own right but is helpful not only during construction but in operating and maintaining a building. Unnecessary variation can be expensive. Again prefabrication is certainly not good in itself but in this case offers better value for money and helping to ensure easier and speedier construction that may cause less disruption on site and later maintenance (Figs. 4.130, 4.131, 4.138, 4.139, 4.140, 4.141).

The hospital's skygardens, in their social context, assist in healing society back to good health, while in their physical context assist in reducing the built environment's carbon sores. 'The planting acts as a carbon sponge, noxious pollutants filter and heat-reducing element—an important feature in a city that crams over 4 million people into a 265-sqmile area'.

As a National Heart Centre, the facility has to have the capacity and ability to absorb changing healthcare practice and to successfully take up and deploy the latest medical technologies from diagnostics to treatment. The modern state-of-the-art facility has the potential to transform the delivery of healthcare in Singapore through application of innovative medical devices. With growing emphasis on faster patient throughput facilitated by the ever-widening range of procedures that can be now undertaken laparoscopically and endoscopically, it is essential that operating theatres are equipped accordingly. Patients can then have their operation, spend minimal time in hospital recovering and are back to normal activities, within as little as a week. Without such positive health outcomes, it is difficult to justify the scale of capital investment required for the 'smart', cutting edge and hybrid

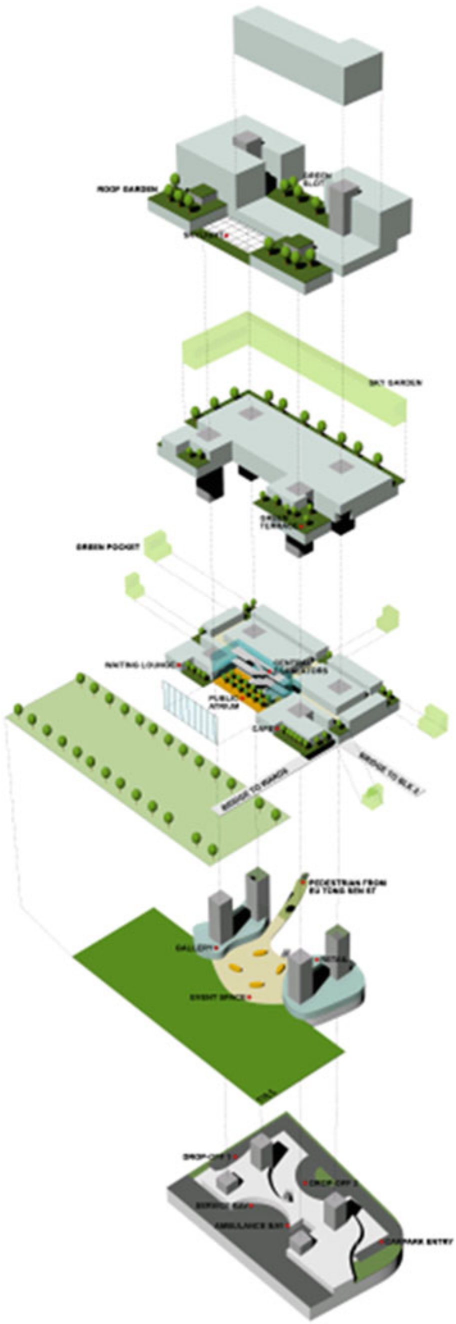

Fig. 4.134 National Heart Centre, Singapore—Design concept (*Source* Broadway Malyan Singapore 2012)

Fig. 4.135 National Heart Centre, Singapore—Waiting areas 2 (*Source* Broadway Malyan Singapore 2012)

Fig. 4.136 National Heart Centre, Singapore—Waiting area and circulation zone (*Source* Broadway Malyan Singapore 2012)

Fig. 4.137 National Heart Centre, Singapore—Information + waiting areas (*Source* Broadway Malyan Singapore 2012)

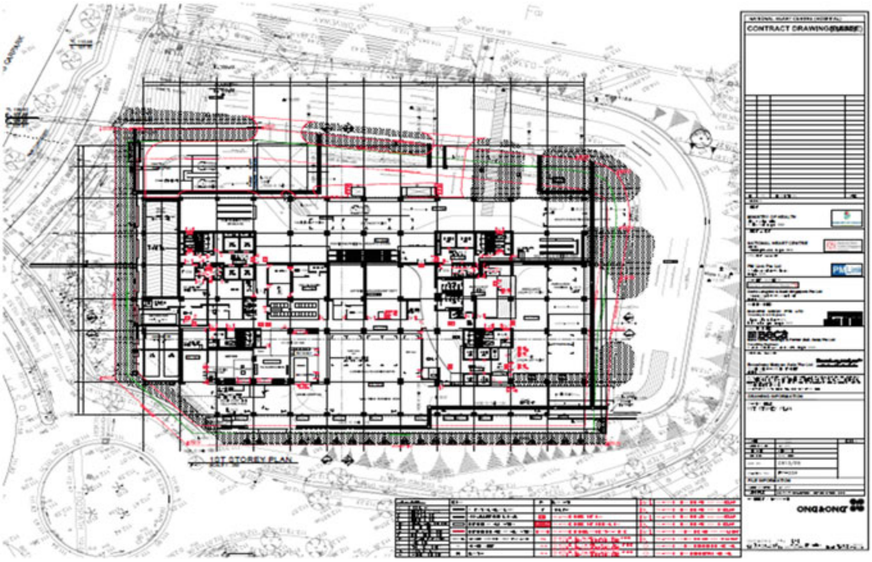

Fig. 4.138 National Heart Centre, Singapore—1st storey floor layout plan: Level 1—Drop-Off Area, FM, Deliveries, VIP Drop-Off and Shuttle Bus (*Source* Broadway Malyan Singapore 2012)

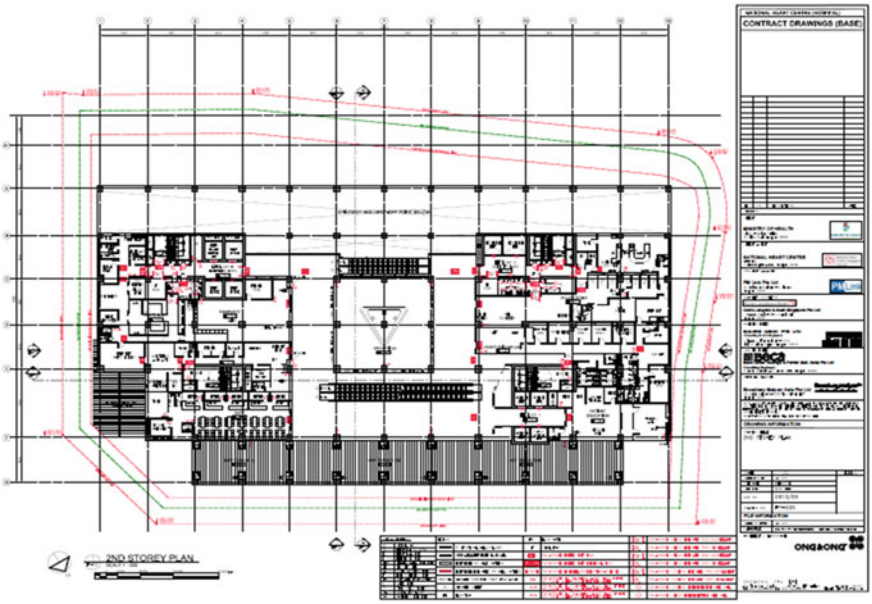

Fig. 4.139 National Heart Centre, Singapore—2nd storey floor layout plan: Level 2—Concourse, Main Reception, Pharmacy, Patient Education, International Medical Services + Phlebotomy Laboratory (*Source* Broadway Malyan Singapore 2012)

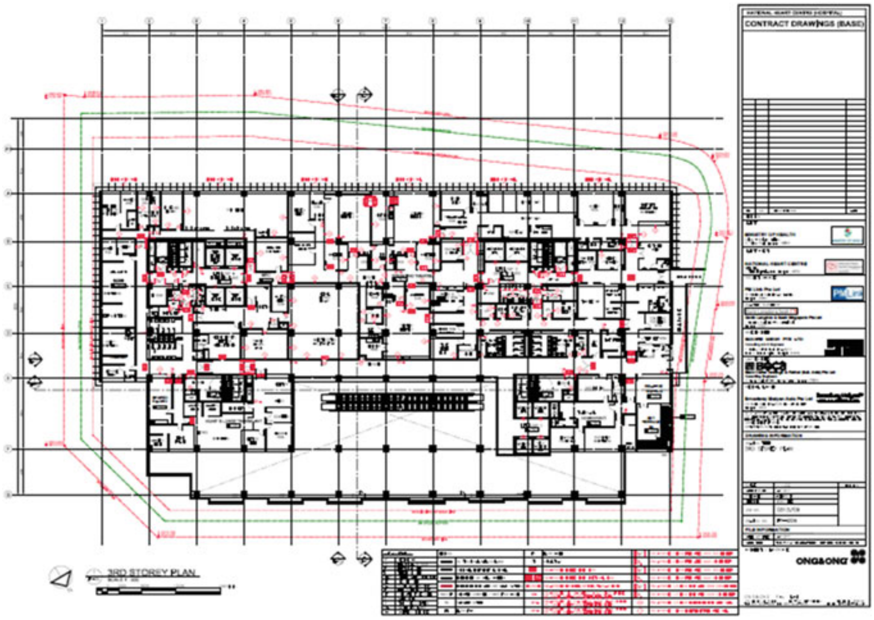

Fig. 4.140 National Heart Centre, Singapore—3rd storey floor layout plan: Level 3—Operating Theatres, Post-Anaesthesia Unit (PACU) with Nurse Base, Medical Records Library, Link-bridge to Existing Hospital/Wards + Homograft Laboratory (*Source* Broadway Malyan Singapore 2012)

theatres. Designing theatres as multi-function and integrated operating rooms for both laparoscopic/endoscopic and conventional open surgery procedures to be performed within the same room is important to enhance operational flexibility, and if data produced by digital X-ray equipment, MRI and CT scanners, is provided as part of a comprehensive package integrating the operating room and critical care equipment which is then seamlessly connected to the hospital records system facilitates joined-up thinking which improves efficiency and effectiveness. In turn, the flexibility has to be supported by the capability of easily and conveniently configuring the operating theatre workstations for different surgery procedures through ensuring the optimal view of the surgery field and increased patient safety via better ergonomics and safety mechanisms, central control of the entire room using touch screens and other interfaces (Figs. 4.130, 4.131, 4.138, 4.139, 4.140, 4.141).

Fig. 4.141 National Heart Centre, Singapore—4th storey floor layout plan: Level 4—Special Outpatient Clinics (SOC), Nuclear Cardiology (*Source* Broadway Malyan Singapore 2012)

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Chapter 5
Emerging Issues

Definitions of 'Evidence' and 'Sustainability'

"The problem of definitions of 'Evidence' and 'Sustainability' is at the centre of and underlies the debates surrounding the interrelated themes of Centralisation versus Decentralisation, the nature of Public versus Private Sector Involvement, National versus International Standards to Prescription versus Performance Standards (Table 5.1)". These definitions have, in recent times, generated a lot of controversy but largely relate to methods of data collection, availability and validation or verification of information. Both terms have had many varied and diverse applications, sometimes used incorrectly and other times abused, resulting in more confusion including, for example, suggestions from some quarters that the inflated meaning of the word 'evidence' should actually be replaced with risk and uncertainty. One reason for the confusion is that the subject matter is fashionable at the moment.

However, in this Brief, the term evidence is used as in Evidence-Based Architectural Healthcare Design by Lawson and Phiri et al. (2003), Ulrich et al. (2008) and Hamilton DK (2008) and refers to data collection and structuring that derive and follow rigours of science. In essence, an evidence database therefore connects structural and process measures of the estate and patients/staff outcomes (Table 5.1).

As a system or mechanism for measuring quality and safety in the healthcare estate, an evidence base indicates how the designed estate can impact length of hospital stay, incidents of trips/falls, rates of cross-infection, medical/medication errors, consumption of medication and other measures showing very detailed results of heart rates, sleep patterns, staff absenteeism and the like. Links to more qualitative measures of patient satisfaction and staff recruitment, retention also refers to international and extensive studies.

A database of such research for the UK Department of Health was started in 2000 with funding from NHS Estates (Lawson and Phiri 2000). The database was updated annually until 2004 when NHS Estates was abolished (Lawson and Phiri 2003). We are now aware of around 700 relevant items of research suggesting that

M. Phiri and B. Chen, *Sustainability and Evidence-Based Design in the Healthcare Estate*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-3-642-39203-0_5,

Table 5.1 Factors in improving environmental quality and safety in the healthcare estate

	Description	Typical application	Benefits/strengths	Other considerations
Centralisation versus decentralisation	*Centralisation* 'Top-down' approach and as largely determined by central government or authority	Health and Safety legislation involving the safety and health of people in and around the building. Planning legislation concerned with, amongst other issues, the siting of the building and its use, its visual impact of the surrounding area and general aesthetics. UK government's design quality improvement agenda implemented via the Department of Health Estates and facilities	Ability and mechanism or instrument to respond directly to changes in health policy and to demands by the government of the day Quality and safety regulations absolve the organisation liability higher than that determined by the regulatory standard	Minimum standards enforced by legislation usually become maximum. Most quality and safety regulations limit competition May adversely and unduly be affected or influenced by fragility of health policy and specifically by short-term operational measures as opposed to strategic long-term issues
	Decentralisation 'Bottom-up' approach as determined by local authority	Care Homes in the UK which are largely administered by local authorities In Sweden, typically, hospitals are the responsibility of the municipalities or local authorities	Ability and capacity to respond to demands of local groups and communities, people or populations	Difficulties of accommodating a wide variety and diverse requirements or resolving conflicting demands

(continued)

Table 5.1 (continued)

	Description	Typical application	Benefits/strengths	Other considerations
National versus international guidance, guidelines + tools	*National* country basis—‘A community of people who share a common language, culture, ethnicity, descent or history’	Worldwide, building control legislation ensures that building and infrastructure projects comply with Building Legislation, a set of construction standards laid down by Parliament. The standards cover requirements on health, structural stability, fire safety, energy use and access by occupants and vehicles	Recognises the country’s building codes, laws and regulations e.g. ASHARE standards and guidelines in the USA, British standards in the UK Reliant on own resources for development and updates Easier consensus- building	National guidance and guidelines may not be transferrable to different countries and cultures with different laws and regulations e.g. different climate
	International Involving several countries and extending beyond or across national boundaries	What society at the global scale does to prevent disease, prolong life, promote and restore health through organised efforts and informed choices, organisations, public and private, communities and individuals	Global alliance and harmonisation facilitates shared technologies, maintenance, updates, costs and innovations e.g. European Standards (EN) Harmonisation leads to economic use of human, material resources, reduces waste and enhances efficiency and effectiveness	Harmonisation requires improved governance, regulation and monitoring to ensure and improve compliance International incentives are essential to encourage compliance while United Nations type penalties or sanctions are required for non-compliance

(continued)

Table 5.1 (continued)

	Description	Typical application	Benefits/strengths	Other considerations
Prescription versus Performance Healthcare Technical Guidance/ Standards + Tools	*Prescription* Authoritative recommendation or action that is authoritatively ordered or recommended	For example, a floor slab might be specified to contain 35-MPa (megapascals) concrete and a specified surface finish in accordance with the appropriate British Standards Another example is the USA Building Codes harmonised under the International Code Council as a transparent method of updating the codes	Prescriptive requirements involve straightforward quantification spelling out exactly how something is to be done and providing useful thresholds or baseline or a comparator. Historically prescriptive requirements are very reactive in that when a problem occurs the building standards/codes change to ensure that the problem never happens again	Imprecision of prescription specifications invites litigation Mandatory healthcare guidance and guidelines or standards do not necessarily lead or translate into design quality and safety improvements. Re-active nature of prescriptive requirements means they can be slow in the face of rapid technological and organisational structural changes
	Performance The manner, in which something or somebody functions, operates or behaves i.e. specifications expressed in terms of expected outcome or acceptable performance standard	Alternatively to the first example above is to specify a floor slab to support a maximum traffic load, defined traffic lanes, racking load and type of forklift. The strength would be dictated by the traffic load and the FF/FL (Floor Flatness/Floor Levelness) numbers determined by the equipment manufacturer for a given rack height and type of operating equipment	Performance specifications merely outline the required level of performance, leaving it up to the designers how this is achieved Offers opportunities for innovation while reducing the regulatory burden. Written requirement describes the functional performance criteria required for a particular equipment, material, component or product	Difficulties of defining specifications expressed in terms of expected outcome or acceptable performance standard including issue of gathering the evidence Performance specifications reduce risk by the designer and transfer responsibility to the builder or contractor limiting their ingenuity and innovativeness. Also increases risk of non-compliance

(continued)

Table 5.1 (continued)

	Description	Typical application	Benefits/strengths	Other considerations
Public versus private sector Involvement in the development of specifications or technical standards	*Public Sector* government-controlled part of the economy i.e. the part of the economy that is controlled by government spending and employment	Generic term incorporating all government organisations and activities, for example, government interventions to change individual behaviours such as drinking, smoking, poor diets and lack of physical exercise. Although 'bureaucratic', such tax financed government action justified on necessary welfare grounds is seen as less 'Market-driven'	Public resources are used to deliver public sector hospitals and infrastructure and/or services according to a specification defined by the public sector	Specifications adopted by the government are rightly or wrongly often seen as mandatory, not voluntary and easily adopted Outsourcing to the private sector is seen as reducing inefficiencies
	Private Sector Privately-owned part of the economy i.e. the part of a free market economy that is made up of companies and organisations that are not owned or controlled by the government	Generic term for all 'for profit' organisations and activities largely seen as more 'Enterprising or entrepreneurial', 'Market-driven' despite the fact that State subsidies, guarantees, 'bailouts' and differential tax advantages underpin profitability and share value	As with funding of hospital and infrastructure projects with private capital, development, updates and maintenance of healthcare guidance and tools can also be carried out in this same way	Apparent risks appear to be transferred to the public sector However, the immediate cost savings can be countered by formidable commitment on revenue expenditure in future years to come

(continued)

Table 5.1 (continued)

	Description	Typical application	Benefits/strengths	Other considerations
Self-Assessment versus independent or third party verification	*Self-Assessment* Verification based on own individual interests and welfare especially when placed before those of others	Tools such as NEAT (NHS Environment Assessment Tool), AEDET Evolution were developed as a self-assessment tools for use by novices and lay men in contrast to DQI (Design Quality Indicator) and BREEAM involving assessors and experts and payment of fees	Specifically, accreditation via self-assessment by a healthcare organisation evaluates its level of performance relative to established standards	Problems if the self-assessment is not validated by an external or objective review team consisting of peers and service users. Creation of voluntary standards requires expertise and knowledge
	Independent or 3rd Party Verification not one of the two main people or organisations involved	Accreditation is the longest established and most widely known form of external assessment of healthcare services in the world involving risk management process, quality and safety improvement system and compliance with predetermined criteria	A measure of objectivity and equity An organisation, which achieves Accreditation means that if and when failings occur that organisation has a system in place to identify them, rectify them and attempt to ensure that they will not re-occur	Validation by an external review team consisting of peers and service users may be costly and requires a review process Where an organisation has achieved Accreditation it is not a guarantee that it will have no failings

factors that the architect/designer has control over can make significant differences to patient satisfaction, quality of life, treatment times, levels of medication, displayed aggression, sleep patterns and compliance with regimes among many other similar aspects. The database was cross-referenced to a similar literature search conducted in the USA by Prof. Roger Ulrich’s team (Ulrich et al. 2004, 2008). Ulrich’s team looked for studies that were as follows:

1. Rigorous and used appropriate research methods that allowed reasonable comparisons and discarded alternative hypotheses. The research studies were assessed on their rigour, quality of research design, sample sizes and degree of control;
2. High impact and explored outcomes of significance to healthcare decision-makers, patients, clinicians and society.

Previously, Rubin et al. (1998) identified 84 studies (out of 78,761 papers) since 1968 that met similar criteria and rigorous standards of hard science. Reviewing the research literature in 2004, they estimated that they would find around 125 rigorous studies. Ulrich’s and Lawson’s teams found more than 600 studies. We therefore have good reason and high confidence in the Sheffield database and believe we identified the overwhelming majority of work in the field internationally. Summarised in a UK Department of Health publication (Phiri 2006), it was published continuously up to 2004 on the UK Department of Health Knowledge Portal, which has been succeeded by the website www.spaceforhealth and is under development at http://hear.group.shef.ac.uk as a facility planning, design and management resource that makes available summaries of all the original research, together with very basic analysis to those people who wish to check or question its validity. Studies referred to in this case range in size and scope, with some small and little more than anecdotal, while others are major longitudinal controlled investigations. Some are multi-factorial and some much more parametric. (Figs. 5.1, 5.2)

The HaCIRIC/EPSRC-funded project Nurturing an evidence-based learning environment (EBLE) that supports the Innovative Design of Healthcare Facilities or similar and the Loughborough University’s commission from the European Investment Bank on the nature of evidence that demonstrates health gain from healthcare infrastructure investment on new hospitals found measures of hospital efficiency, volume–outcome, care-closer-to-home, ‘Care-in-the-Community’, access, adaptability and flexibility, reduction in waste or in carbon emissions a vital consideration and of relevance. The Center for Health Design highlights the challenges in reaching an optimal understanding of the complex and interacting factors that characterise the care environment. Myriad factors from multiple domains, for example, treatment, workflow, processes, cultures, policies, physical environments, sociological and psychological processes at both the individual and group levels interact in complex ways in care delivery and healing (Quan et al. 2011, p. 65). A lack of common definitions, tools, measures and metrics associated with the physical environment is a major obstacle to further research and the development of theoretical frameworks that are based on meaningful study outcomes and facilitate translation of study findings to aid design decision-making

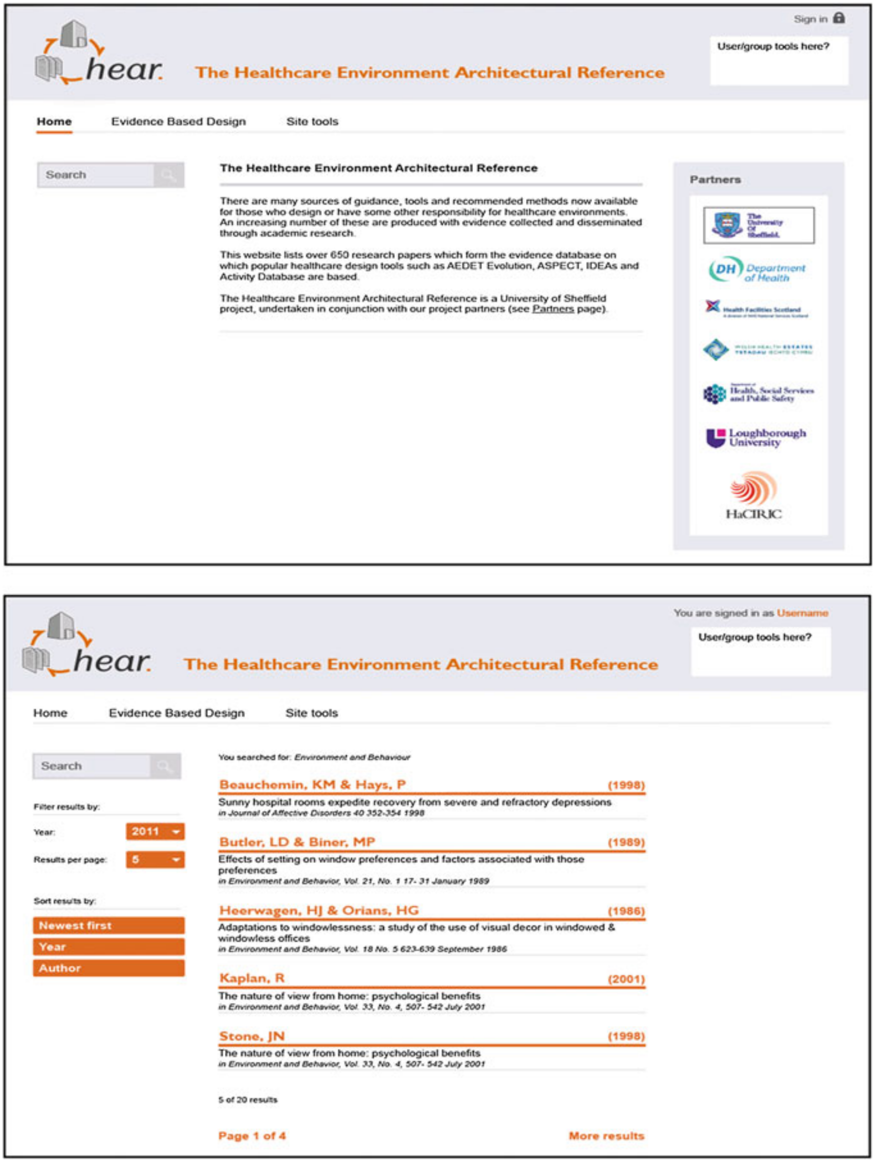

Fig. 5.1 The healthcare environment architectural reference (HEAR) 1–2 http://hear.group.shef.ac.uk

and production of guidance and tools. Gathering baseline data on the factors is particularly complex because of the intersection of the many specific application areas and themes other than sustainability and evidence-based design. The nature of the data collection on these factors and evaluation using the hard science

Fig. 5.2 The healthcare environment architectural reference (HEAR) 3–4 http://hear.group.shef.ac.uk

methodology poses a challenge for the development of the evidence base. Also, the drive for efficiency in health care needs reconciling with the goal of therapeutic environments.

Fable Hospital 2 in 2011 (Sadler et al. 2011 based on Sadler et al. 2008) has distinguished evidence-based Innovations supported by evidence from innovations supported by experience but warranting further study. The evidence-based innovations supported by research evidence include large single-inpatient rooms, acuity adaptable, larger windows, larger patient bathrooms with double-door access, ceiling-mounted patient lifts, enhanced indoor air quality, decentralised nursing substations (alcoves), hand-hygiene facilities, medication area task lighting, noise-reducing measures, energy and water demand reduction, e-ICU comprehensive remote ICU monitoring capability, healing art, positive distraction measures and healing gardens. Design innovations supported by experience but warranting further study include family/social spaces, improved 'way-finding', Health Information Resource Centre, respite areas, staff gym, decentralised nursing logistics and environmentally responsible materials.

The term sustainability as used in the context of this brief refers to both sustainable building and sustainable building-in-use. Construction sustainability includes 'considering sustainable development in terms of three primary aspects (economic, environmental and social), while meeting the requirements for technical and functional performance' (ISO 15392, 2008). From an economic point of view (i.e. minimised life-cycle costs), green or sustainable building combines the following:

- High comfort and optimised user quality.
- Minimised energy and water consumption.
- Resource conservation (material cycle as a crucial factor when choosing between different materials).
- Climate-friendly energy production.
- Low output of pollutants (e.g. decreased CO_2 emissions).
- Health protection.

The multi-facets of sustainable development include interrelated environmental, cultural, social and economic factors.

1. Environmental Sustainability: What have been the forms and effects of human interventions on nature? How can we create a viable home for human beings and all other life forms of the planet?
2. Cultural Sustainability: How does culture forge a productive diversity for the human species as well as nurture the sources of cohesion in ways of seeing, ways of thinking, ways of meaning, ways of relating to each other and ways of connecting with nature?
3. Economic Sustainability: How can we create economic systems which are environmentally, culturally and socially viable?

4. Social Sustainability: What allows for all our participation as autonomous yet social beings? How do we promote good citizenship and ensure justice? How do we integrate the four fundamentals of environment, culture, economy and society so we can address our human futures and live to the fullest of our human potentials?

All this means that the adverse impacts of noise, pollution, toxity and waste emissions will be minimised. Opportunities for reducing energy and water consumption will be maximised. Attention to sound environmental management will extend beyond the capital project to the maintenance and operation of the building.

A major problem in applying the broader definition of sustainability is that scholars and practitioners have largely approached sustainability from the standpoint of environmental protection and resource management. The need is for an integrated approach to sustainability is to avoid possible trade-offs among the different dimensions during policy design and implementation. For example, in a paradoxical way, initiatives oriented towards fostering mobility may lead to increase in environmental pollution, while programs to contain the ecological impacts of mobility may undermine social justice and increase inequalities. However, encouraging the construction of green buildings from within the context of larger sustainability plans (including the issue of climate protection) can help us to realise their greater potential that includes an enhanced capacity for constant innovation in terms of technology and construction practice into green building policies.

Centralisation Versus Decentralisation

In the UK, the development of healthcare guidance and tools has mirrored the changes in the organisational structures in England including a direct relationship with the historic levels of NHS investment, indicating real-term funding doubling since 1999 to enhance NHS capacity. Centralisation versus decentralisation has been an important driver especially in terms of the necessary development work. Different procurement routes notably Design/Build; PFI, PPP etc. have all had a significant influence.

The need for guidance and tools in health care has been demonstrated by studies which found designers express a desire for supplementary technical information, but only if this has been assimilated into designers' terms and is readily accessible (Tétreault and Passini 2003). In order to enhance usability, there was need to furnish information on research results as recommendations or guidelines just like functional and technical regulations and include literature reviews or lists of references to allow further study. The studies suggest that government agencies should undertake this work of researching this knowledge and distributing it widely. Also as information entering design offices ha to suit the goals of the clients; the clients ought to motivate an interest in information coming from research.

However, providing ‘guidance and standards’ for Health Service facility design and procurement is more complex than was anticipated when the famous Hospital (Health) Building Notes, which became the world’s first point of reference in the field of hospital planning information were produced from 1961.

Mandatory healthcare guidance and tools appear to have an unsatisfactory evidence base to meet the growing focus on designing with evidence or to recognise that designers, who certainly always applied evidence from structural and civil engineering, mathematics, geometry physics, material science, fluid dynamics, real estate economics and so on, but are increasingly being asked to turn to unfamiliar domains, domains for which customarily they have no educational foundation (Hamilton 2008).

Updates and revisions to guidance and tools are not made on a regular basis to incorporate latest research results and building technologies and to reconcile the three models—Care model, Estates Strategy and Physical model. This is largely because of a lack of recognition that resources especially overtime are finite, competing with other needs and cannot be guaranteed. The major investment in the development of guidance and tools is not in the initial costs but in the subsequent resources requiring both technical and financial capabilities to maintain and keep them up to date. Planning and design data are only useful if it is fresh, and keeping a database up to date is a big job which requires long-term commitment and appropriate investment. Without appropriate resources, an ‘efficient’ system cannot be implemented or effectively maintained.

Dangers of Ignoring the Past

Since the 1980s, major lessons in the UK indicate lost or poor knowledge transfer e.g. dimensional coordination and the associated benefits of rationalisation in the context of economy, speed and quality assessment. Related to this has been the absence of feedback linked to the loss of evidence from the past.

A good deal of light is thrown onto the problem of healthcare capital planning and investment from the conclusions of The Howard Goodman Fellowship Report (Barlow et al. 2009) in particular:

1. There are barriers in communication between designers and users, for example, communication and collaboration between the trust and special purpose vehicles and subcontractors are often difficult and disrupted because of contractual

arrangements. For the designers, there appears to be two ‘clients’—the special purpose vehicle and the traditional client, the hospital and its users.
2. Transfer of knowledge within and between projects is limited. Systematic capture of experience on PFI projects by trusts is largely absent. There is pressing need to learn from the history as well as from the experience of developing new hospitals under the PFI model. *The PFI model may have been less effective in stimulating design innovation than the system it replaced. That system involved greater coordination throughout the NHS. The lesson of all this for those wishing to nurture innovation today is that we also need to think ahead about capturing and disseminating learning.*
3. Continuous reorganisations of the NHS stifle innovative thinking and the *focus on the future*. NHS culture tends to concentrate on *fulfilling today’s needs* as opposed to thinking long-term. *The old model of strategic planning by the UK central government department—plus implementation by regional and area authorities—no longer applies.*

- In the UK, especially central and local government have been outsourcing their technical skills (Bordass 2003). For example, the UK no longer has a Property Services Agency; in spite of a massive school building programme, there is no longer a Design Research Unit in the Department of Education; and the technical departments in local authorities are shadows of their former selves. Similarly, in the healthcare sector, NHS Estates was abolished in circ. 2005.
- Central government has outsourced its research too. In the UK, the Building Research Establishment (BRE) was privatised in 1997 shortly after its 75th anniversary. It is now a consultancy. No longer does government have a single authoritative source of disinterested or impartial information to which to turn.
- Government perpetuates a category error in seeing ‘the construction industry’ as the experts on building performance. In fact, the industry designs and alters buildings, but does not know much about how they perform in use. For the most part, it hands over the keys and has no continuing involvement or interest.
- In spite of the talk about whole-life costing (e.g. OGC 2007), splits between capital and operating expenditure are rigid. It proves difficult in practice to set aside capital budgets to include aftercare, tune-up and feedback after building work is over. It is proving equally difficult to fund these activities from operating expenditure brought forward. For example, in the UK, we have private finance initiative (PFI) finance, design, build and operate packages that might be expected to link things up. However, inside the package, responsibilities can be even more tightly divided up than ever, e.g. with the project being sold on after it has been built; and if feedback is obtained, it tends not to be shared.

Public Versus Private Sector Involvement

The balance between Public versus Private sector involvement is an important issue in the responsibilities of developing healthcare guidance and tools. The development of healthcare guidance and tools needs assurance of continuous investment to ensure that updates are made regularly and consistently to respond to technological and other changes in the care models. Also, when considering strategy for developing healthcare guidance, three fundamental problems need to be addressed: the fragility of health policy; the general speed of change; and the chronic complexity of management or organisational structures.

Mandatory healthcare guidance and guidelines do not necessarily lead to design quality and safety improvements although strong and clear guidance appears to underline the importance of design quality. Even endorsement by the Department of Health such as that accorded to activity database is no guarantee of quality and safety improvements on the ground. Dogmatic compliance itself or strict adherence to mandatory healthcare guidance and tools can serve to stifle both creativity and innovation, leading to poor designs.

A gap persists between evidence-based operational protocols to support decision-making, building performance standards that are informed by the best evidence while relating to health outcomes. This needs to be addressed, facilitated by a rigorous, transparent development process that is consistent and reliable. A key task is providing an account of the state of the evidence that is internationally recognised for its excellence and research that is designed to promote good health and prevent ill health with a clear strategy for future studies.

National Versus International Standards

Yet another challenge is the cost of development of work i.e. the research, testing and publishing of the building standards/guidance. A large number is unsustainable and increases the regulatory burden while reducing compliance (Fig. 5.3).

Advantages for any individual country developing its own ensemble of guidance and tools include the ability to relate these to that country's legislation, healthcare policies and peculiar circumstances. It avoids external dependence. However, a decision for the country to develop and maintain its own guidance system and tools can be costly and requires intellectual expertise.

Pooling of financial and intellectual resources to produce guidance/norms that remain currently and technically sound can be carried by utilising standards organisations (ISO Standard 14020 2000, ISO Standard 14040 2006, ISO Standard 15643-1 2010, ISO Standard 21931-1 2010). This is often a viable option to avoid duplication. Specifically in the UK, the acceptance or high valuation of the NHS by successive governments since the NHS Act 1947 which introduced it should be accompanied by a corresponding capital commitment underpinned by a manageable set of guidance and tools.

Prescription Versus Performance Standards

A major challenge in developing core standards is determining the balance between prescriptive and performance requirements. Prescriptive requirements spell out exactly how something is to be done, and performance requirements merely outline what the required level of performance is leaving it up to the designers how this is achieved offering opportunities for innovation while reducing the regulatory burden. Historically, these prescriptive requirements are very reactive in that when a problem occurs, the building standards/codes change to ensure that the problem never happens again. The USA building codes harmonised under the International Code Council provide an example of primarily prescriptive requirements and offer an interesting transparent method of updating the codes. Public hearings are held regularly throughout the country, and any interested party or individual may make representations for changes to the codes. The representations are then considered by a panel of experts and advisors with deliberations and decisions announced via the Web (Fig. 5.3).

In recent years, the increasing trend is a move away from most of the prescriptive building standards to more performance and less prescriptive requirements. A number of countries have pursued the performance approach to regulation, while one country, Canada, has abandoned performance codes as unworkable, and adopted an objective-based code with a mixture of performance and prescriptive approaches. Several countries, for example Australia, are also moving to much shorter objective-based building standards and codes. Rather than prescribing specific details, objective codes list a series of objectives all buildings must meet while leaving open how these objectives will be met. When applying for building permissions, the designers must demonstrate how they meet each objective. The problem is that performance-based building standards are

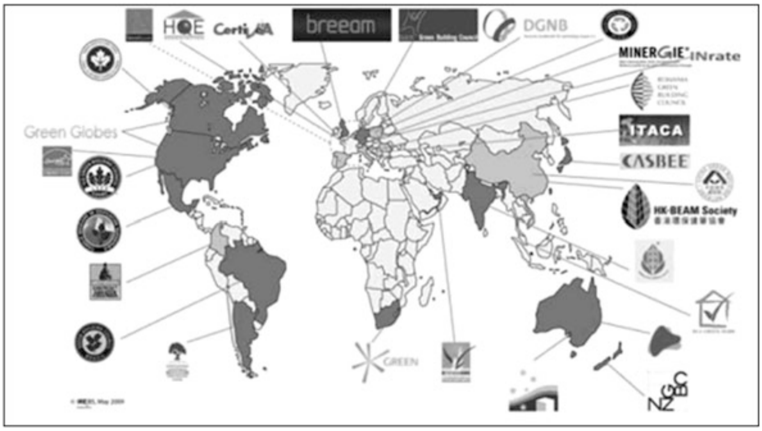

Fig. 5.3 National versus international technical healthcare guidance, standards and tools

principally concerned with health, safety and amenity issues for building occupants. Research is needed to identify the minimal set of generic guidance/standards and tools which impact design quality. The issue of standards relates to that of standardised workflows. Over-complex non-standardised workflows can impact negatively on the production of standards themselves.

Self-Assessment/Self-Assurance Versus Independent or Third Party Verification

An emerging issue of how healthcare guidance and design tools should be implemented in practice and by whom relates to the definition of ‘evidence’ above. Worldwide, there has been a growing trend towards an expansion of regulatory capacities of the state, even though often through the context of decentralised fragmented forms, which include hybrid cross-cutting organisations (Mackenzie and Martinez Lucio 2005). However, two situations ought to help us illustrate the nature of the problem of self-assessment, self-assurance and self-regulation. First we have a situation in which the national governments have developed healthcare policies and then sought to implement these directly, for example in the UK via the Department of Health. To do this, the Department of Health has produced Healthcare Guidance and Design Tools as mechanisms to ensure compliance with health policy requirements and directives.

In addition, in the UK, the recent development of the premises assurance model (PAM) as a system-wide nationally consistent approach to providing organisation board-level assurance of the premises in which NHS clinical services are delivered is one practical response to this issue of how healthcare guidance and design tools should be implemented. The Premises Assurance Model is an important component in overall vision for quality and quality improvement in the NHS (*High Quality Care for All*, Darzi 2008). The methodology is a rigorous self-assessment, backed by evidence and measurements to demonstrate that a healthcare provider’s premises achieve the required statutory and nationally agreed standards in terms of safety, effectiveness and patient (user) experience. Therefore, PAM sets out for a provider organisation a performance spectrum across a range of key deliverables in 5 domains: 1. Finance/Value-for-money, 2. Safety, 3. Effectiveness, 4. Patient Experience and 5. Board Capability. This mechanism supports:

- An organisation’s ability to demonstrate baseline compliance for registration and regulation.
- A verifiable demonstration that premises are playing their useful part in supporting the objectives of the UK NHS Operating Framework.
- A verifiable demonstration that premises comply with the associated performance management system (the UK NHS Performance Regime).

In each of these cases, the UK Department of Health System of guidance and toolkits has an important role to play in order to achieve performance and quality improvements. PAM is aspirational and has the dual aim of first seeking to lift premises assurance from an operational perspective into a strategic objective and second, raising a healthcare organisation's appreciation of the vital role that NHS premises play in the delivery of improved clinical and social outcomes. PAM is being co-produced with the NHS and relies on a 'bottom-up' rather than a 'top-down' approach to providing and developing healthcare premises planning information and design tools.

The second situation is apparent in the development of design tools, for instance the environment assessment methods such as BREEAM, LEED™ and others in which registration and certification is the norm. Registration and certification bring with them assurance by another party that a certain process (e.g. evidence of sustainability considerations, quality assurance and expert audition) has been followed to achieve the outcomes. However, to ensure rigour and verification, training of healthcare assessors and technical support regimes are established with registration fees levied from users to recover costs. Fees, registration and access via assessors are an obstacle and mean that the tools are not freely available to potential users. The system of registration and building certification offers advantages of a level of continuous renting, income from renting, selling price aspects, which facilitate private sector involvement. In turn, this allows continuous development of the tool using funds obtained from fees for managing the tool, for registration and for training of assessors and from proceeds from marketing (Fig. 5.4).

In the UK, the Department of Health has also been responsible for initiating, sponsoring and funding design tools such as AEDET Tool and NEAT as self-assessment tools to meet its agenda for sustainability and design quality improvement. A huge advantage of self-assessment tools is that they are freely available. In this case, there are no registration fees and no requirements to obtain a certificate. The endorsement by the Department of Health gives the healthcare guidance and tools a source of authority and credibility of a publicly owned asset. Users of the tools rightly or wrongly feel that these are actually government sponsored and therefore based on well-researched accurate information. However, the major problem with self-assessment or self-assurance is the verification of both the process and outcomes. There is therefore no guarantee that the process has been rigorous or that the outcomes are valid. With these self-assessment tools as with private sector tools such as BREEAM, LEED™, it is crucial that there is on-going funding and support from the sponsors to ensure R&D investment, the continuous development of the healthcare tool, that the tool is fit for purpose, is updated and responds to changing technologies or clinical practice. The problem is that expenditure is often seen as a one-off and often competes with other needs of the day.

Self-assessment versus Independent Verification does not necessarily mean Private versus Public involvement. Healthcare guidance and tools have also been and are often initiated, sponsored, funded and developed by not-for-profit

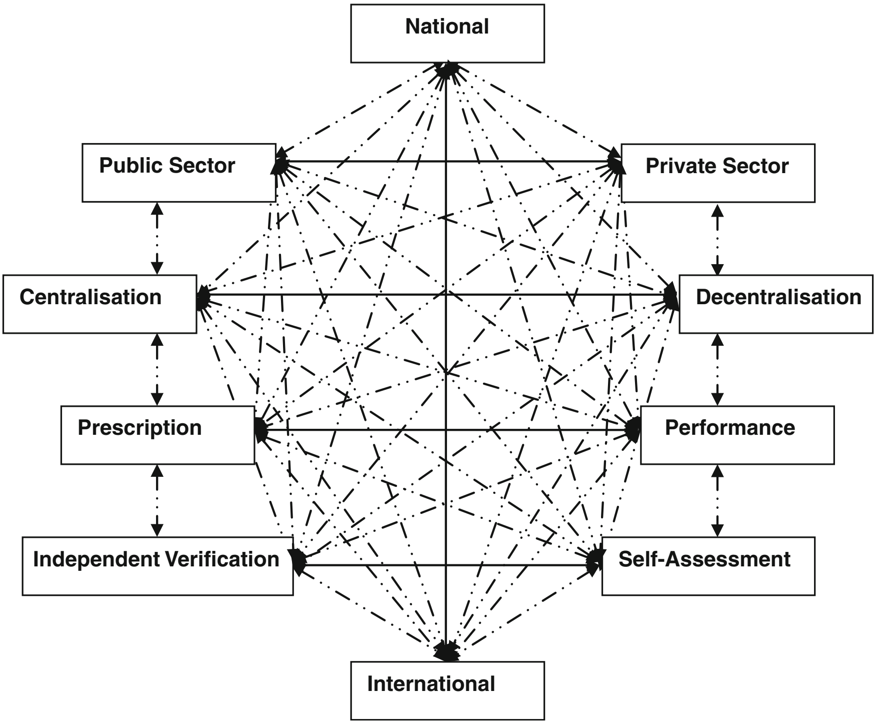

Fig. 5.4 Diagrammatic representation of the complex nature of the interrelationships of the emerging underlying issues of implementing healthcare technical guidance, standards and tools for improving quality and safety

organisations, universities and/or educational institutes, professional organisations (e.g. CIBSE TM22 Energy Assessment Tool by BSRIA) as well as by collaborations between these and sometimes partnering national government agencies.

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Chapter 6
Conclusions

Discussion and Concluding Remarks

As a practical solution to the perennial problem of data collection and well-designed methods of study, this brief suggests that every healthcare project ought to be considered and set up as research with the explicit goal of gathering 'before' and 'after' sample robust data (evidence) that is then analysed to discover the extent of changes and what the agendas for sustainability, quality and safety improvement have achieved overtime. Using and conducting research as a part of the healthcare facility, design–construct–occupy process alone is inadequate and needs to be accompanied by a change upstream in the way architecture is taught, particularly accepting a focus on health care as a part of the curriculum in architectural design for the university design and architecture programmes (Table 6.1).

All this means a cultural change as well as developing a culture within the healthcare industry that firstly, conducts rigorous and longitudinal research that demonstrates the relationship between specific design strategies or interventions and outcomes; and secondly, routinely carries out post-project evaluations in order to obtain feedback that feeds forward into future projects. The development of tools for translating and conducting research is another much needed activity to aid practitioners.

Lessons from the case studies are extremely helpful. As a whole, the case studies demonstrate the importance of embracing the principles of design for sustainability integrated with evidence-based design by individuals and by the organisations to which these individuals belong to from the small-scale projects such as Houghton-Le-Spring Primary Care Centre, Sunderland, UK, to the massive large-scale hospital project such as the First People's Hospital, Shunde District, Foshan, China.

The set of case studies demonstrate that healthcare guidance/standards and tools do have the potential to enhance quality and safety in the healthcare estate. They show that in adopting an approach that integrates sustainability and evidence-based architectural design, agreements, legislation and regulation are essential at regional, national and international levels to promote biodiversity, shared

M. Phiri and B. Chen, *Sustainability and Evidence-Based Design in the Healthcare Estate*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-3-642-39203-0_6,

Table 6.1 Summary comparison of the case studies approaches to design for sustainability coupled with evidence-based healthcare design

	First People's Hospital, Shunde District, Foshan, China	Glenside Campus Re-development, Adelaide, Australia	Houghton-Le-Spring Primary Care Centre, Sunderland, UK
Evidence-based architectural design and corresponding interventions	• Improve patient safety and outcomes, staff efficiency and effectiveness • Increase patient, family, and staff satisfaction • Accommodate today's best practices • Provide flexibility to adapt to the future	**Meet requirements of model of care:** • A place of refuge, safety, security and healing • Demystification, destigmatisation, autonomy and integration • High standard of aesthetic quality and park-like settings • Accommodation of diversity *Post occupancy evaluation* Aims to evaluate the design of the new healthcare facilities in their ability to meet the requirements of the new model of care. This provides evidenced-based proof that the redevelopment was worthwhile and beneficial	**Improve health + social care in a local geographical area** • Rehabilitation and enabling people to acquire skills for daily living to live more independently • Bring care nearer to where patients live and work • A catalyst for health service modernisation • Facilitate reconfiguration of service delivery models • Offer opportunities for partnership working to promote public health focusing on outcomes such as heart disease, obesity and cancer + environment prevention, early detection/diagnosis and treatment • Create 'nodes' of integrated health and social care services
Sustainable design features and interventions	**Green hospital building evaluation criteria (2**–3*** star)** 4.0.09 Building shape coefficient 4.0.10 Onsite acoustic environments 4.0.11 Wind speed 4.0.12 Large hard pavement areas 4.0.13 Use local green plants. 4.0.14 The location of the hospital 5.0.11 People-oriented principles 5.0.12 Internal spaces 5.0.13 Use solid and durable materials 5.0.14 Negative impacts of building's non-structural elements 5.0.15 Use elastomeric floors. 6.0.9 Monitor energy, water, gas and other supplies 6.0.10 Building equipment 6.0.11 Electricity-driven air-conditioning water chillers and unitary air conditioners 6.0.13 Debugging test for HVAC systems 6.0.14 Load or load loss of the 10/0.4 kV transformers. 6.0.15 Location of transformer and distribution substations 6.0.16 Use water-saving facilities 6.0.17 Control systems for artificial lighting 6.0.18 Information systems 7.1.13 Use natural ventilation first for rooms 7.1.16 Filters for fresh air 7.1.17 HVAC systems for clean rooms 7.2.10 Noise control for power sources 7.2.11 Recycle and deposit dangerous materials 8.0.8 Reduce energy consumption, save water, reduce pollutions + wastes 8.0.9 Encourage green transport 8.0.10 Measure energy consumption 8.0.11 Resilience capacity of technical systems 8.0.12 Protection measures to store harmful chemicals 8.0.13 Quality of all gases 5.0.17 Use ecological measures 5.0.19 Use frame structure 6.0.19 Use energy- and water-saving measures based on the whole life	**Alternative approach to building assessment method** *A Project Collaborative Workgroup* that will also be responsible for ongoing monitoring and assessment established **Sustainability key result areas** with measurable **performance targets for** • **Energy** (0.86 MJ/m^2 per annum) to reduce energy consumption, • **Water** (0.25 kL/m^2 per annum) to reduce water usage, • **Daylight** (Daylight factor of 2 or greater achieved in excess of 45 % of regularly occupied spaces) and • **Waste** (A minimum of 80 % reduction in construction waste destined for landfill) including recycling and reuses of waste generated **Environmentally sustainable design initiatives: glazing design—**Double-glazing specified in critical comfort areas, **Insulation—**Building material properties to exceed BCA standards by 20 %, **Daylight—**Simulations undertaken to optimise relationship between daylight penetration, solar glare and solar heat gains, **High-efficiency, high-frequency fixtures** chosen to reduce health-issued associated with low frequency flickering, **Low VOC materials low + formaldehyde** products adopted to maintain a high standard of indoor air quality, **Internal noise levels** assessment, **Sub-metering** used on all energy uses above 100 kVa, **Lighting power density** minimised with AS/NZS 1680 requirements met, **Lighting zoning—**All individual	**BREEAM healthcare 'Outstanding' rating** A number of integrated low-energy features: • A boiler system coupled to a 500 kWth ground source heat pump • Thermal mass to provide passive cooling during summer • A 350 m^2 mono-crystalline solar photovoltaic array mounted on the roof • Roof mounted 10 m^2 solar thermal arrays • A 5.5 kw wind turbine • Building envelope U-values enhanced 20 % above the min. requirements and the air permeability rate enhanced 40 % above the min. requirements of building regulations Approved Document L. To gain a BREEAM **Outstanding** (>85 %) Rating includes mandatory or compulsory credits + scoring 85 % or more: – **Management**: Man 1–Commissioning Man 2–Commissioning Man 2–Considerate Constructors Man 4–Building User Guide – **Health and Wellbeing**: Hea 4-High-Frequency Lighting. Hea 12-Microbial Contamination – **Energy**: Ene 1-Reduction of CO2 emissions—a minimum of 10 points must be awarded (i.e. an EPC of 25 of less for a new build office)

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Table 6.1 (continued)

	First People's Hospital, Shunde District, Foshan, China	Glenside Campus Re-development, Adelaide, Australia	Houghton-Le-Spring Primary Care Centre, Sunderland, UK
	analysis 6.0.20 Use intelligent lighting control system 6.0.26 Use integrated measures that proved reliable and financially feasible. 7.1.18 Improve natural lighting 7.1.19 Use outside shading 7.1.20 Using air quality monitoring system. 8.0.14 Recover the natural environments damaged during the construction 8.0.15 Reduce rainwater + light pollution, heat island effect. 8.0.16 Reward schemes for green transport modes. 8.0.17 Have technical update for facilities or equipments 8.0.18 Choose energy +water saving and green goods. 8.0.19 Monitoring systems for building equipment. 8.0.21 Rebuilding plans after natural disaster or emergency. 8.0.22 Evacuation plans	and enclosed rooms separately switched, **Automated lighting controls** used in staff areas, **Efficient external lighting** specified, **Openable windows** in all client areas + widened set points in office areas, **Automated off HVAC controls** to improve energy efficiency, **Renewable energy generation—**5 kW photovoltaic installation, **Water efficient fixtures and fittings** specified, **Rainwater harvesting** used for all flushing requirements, **Reclamation of contaminated** land**, Vegetated swales + sensitive planting** schedule allowing for drought tolerant landscaping, retention + enhancements of biodiversity, **Ample bicycle storage** provision, **All refrigerants** used in HVAC have a zero ozone depletion potential, **light pollution** minimised, **Construction waste landfill** diversion**, Portland cement substitution—**30 % in situ, 20 % pre-cast and 15 % stressed concrete, Use of **recycled materials, Environmental Management Plan** implemented	Ene 2–Sub-metering of substantial energy uses Ene 5–Low or zero carbon technologies – **Transport:** – **Water**: Wat 1–Water Consumption. Wat 2—Water Meter. – **Materials**: – **Waste**: Wst 3—Storage of Recyclable Waste. – **Land Use + Ecology**: LE 4—Mitigating Ecological Impact. – **Pollution:** – **Innovation:** BREEAM—In-Use-Certification within the first 3 years of operation is mandatory. This involves (a) Collecting user/occupier satisfaction, energy + water consumption data, (b) Using the data to maintain expected performance, (c) Setting reduction targets, monitoring water + energy consumption, and (d) Providing annual consumption and satisfaction data to the design team/developer and BRE. Also, the building has to be published as a case study (written by BRE Global)

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Table 6.1 (continued)

	National Heart Centre, Singapore	New Parkland Hospital, Dallas, USA	The New University Hospital, Aarhus, Denmark
Evidence-based architectural design and corresponding interventions	**Concept is based on 7 key design considerations**: (1) *'Places People First'* be they the patient, doctor or visitor (2) Incorporates open places at the heart of the design (3) Establishes a world-class facility (4) Provides a social + physical connectivity to the urban fabric and the social structure (5) Creates a structure that is flexible and adaptable to change, (6) Uses modern methods of modularisation to facilitate and an ease and speed of construction and (7) Defines a green benchmark for design in South-East Asia	• Improve patient safety and outcomes, staff efficiency and effectiveness • Increase patient, family, and staff satisfaction • Accommodate today's best practices • Provide flexibility to adapt to the future	**"Healing Wheel of the Environment"** • Improve patient safety and outcomes, staff efficiency and effectiveness • Increase patient, family, and staff satisfaction • Accommodate today's best practices • Provide flexibility to adapt to the future
Sustainable design features and interventions	**Green mark initiatives** achieving **a Green mark score of 92.75** out of **160** Platinum—[PART 1 energy efficiency, PART 2 water efficiency, PART 3 environmental protection, PART 4 Indoor environmental quality and PART 5 Other Green Features] The lower score on renewable energy is probably explained by the urban location of the centre. Key features include daylighting and views, energy efficiency and adjustable air conditioning achieving maximum scores 42 out of 42 in the Green Mark Initiatives for the items Building Envelope and Air-conditioning System. A green benchmark for healthcare design in South-East Asia and a global precedent for sustainable heart-related healthcare development through a rigorous environmental, social and economic design. Construction uses a modular method to help expedite the construction phase of the project. Recognising the correlation between the healing properties of natural light and planting, the design concept draws inspiration from the medicinal courtyard gardens of the past monasteries, from whence the term hospital (from the Latin '*hospes*') (from Medieval Latin *hospitle*, from neuter of Latin *hospitlis*, of a guest, from *hospes*) originates. The skygardens, in their social context, assist in healing society back to good health, while in their physical context assist in reducing the built environment's carbon sores. "The planting acts as a carbon sponge, noxious pollutants filter and heat reducer—an important feature in a city that crams over 4 million people into a 265-sq-mile area".	**LEED[TM] healthcare 'Silver' Certification** (50–59 points) [*Required Prerequisite Credits*: **Sustainable Sites** (SS Prerequisite 1—Construction Activity Pollution Prevention); **Water Efficiency** (WE Credit 3.1—Water Use Reduction); **Energy and Atmosphere** (EA Prerequisite 1-Fundamental Commissioning of Building Energy Systems; EA Prerequisite 1-Fundamental Commissioning of Building Energy Systems; EA Prerequisite 2—Minimum Energy Performance; EA Prerequisite 3—Fundamental Refrigerant Management); **Materials and Resources** (MR Prerequisite 1-Storage and Collection of Recyclables); **Indoor Environmental Quality** (EQ Prerequisite 1-Minimum Indoor Air Quality Performance; EQ Prerequisite 2—Environmental Tobacco Smoke (ETS) Control)] [*Potential additional credits:* **sustainable sites** (SS Credit 4.1: Alternative Transportation: Public Transportation Access; SS Credit 4.2: Alternative Transportation: Bicycle Storage and Changing Rooms; SS Credit 4.4: Alternative Transportation: Parking Capacity: SS Credit 7.1: Heat Island Effect: Non-Roof; SS Credit 8: Light Pollution Reduction); **Water Efficiency** (WE Credit 1.1: Water Efficient Landscaping: Reduce by 50 %; WE Credit 2: Innovative Wastewater Technologies; WE Credit 3.2: Water Use Reduction: 30 % Reduction); **Energy and atmosphere** (EA Credit 1: Optimise Energy Performance; EA Credit 3: Enhanced Commissioning; EA Credit 4: Enhanced Refrigerant Management; EA Credit 5: Measurement and Verification; EA Credit 6: Green Power); **Materials and Resources** (MR Credit 2.1: Construction Waste Management: Divert 50 % From Disposal; MR Credit 4.1: Recycled Content: 10 % (post-consumer + 1/2	**BREEAM healthcare 'Excellent' rating** • Modelled after an existing Danish town, Ribe • Optimum use of daylight/natural light. • Good acoustic qualities for a good indoor climate. • Careful selection of energy efficient light fittings and artificial light sources. • Use of products with a positive effect on the indoor climate. • Minimise dependence on the technical installations To gain a BREEAM **Excellent** (> 70%) Rating includes mandatory or compulsory credits + scoring 70 % or more : – **Management**: Man 1–Commissioning Man 2–Considerate Constructors Man 4–Building User Guide – **Health and Wellbeing**: Hea 4–High-Frequency Lighting Hea 12–Microbial Contamination – **Energy**: Ene 1–Reduction of CO2 Emissions—a minimum of 10 points must be awarded (i.e. an EPC of 25 of less for a new build office) Ene 2–Sub-metering of Substantial Energy Uses

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Table 6.1 (continued)

First People's Hospital, Shunde District, Foshan, China	Glenside Campus Re-development, Adelaide, Australia	Houghton-Le-Spring Primary Care Centre, Sunderland, UK
	pre-consumer); **Indoor Environmental Quality** (EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy; EQ Credit 4.1: Low-Emitting Materials: Adhesives and Sealants; EQ Credit 4.2: Low-Emitting Materials: Paints and Coatings; EQ Credit 4.3: Low-Emitting Materials: Carpet Systems; EQ Credit 4.4: Low-Emitting Materials: Composite Wood and Agrifibre Products; EQ Credit 6.1: Controllability of Systems: Lighting; EQ Credit 6.2: Controllability of Systems: Thermal Comfort; EQ Credit 7.1: Thermal comfort: Design; EQ Credit 7.2: thermal comfort: verification; EQ Credit 8.1: daylight and Views: daylight 75 % of spaces; EQ credit 8.2: daylight and Views: views for 90 % of spaces); **Innovation in design** [ID Credit 1–1.4: Innovation in Design; ID Credit 2: LEED accredited professional (AP)]; **Regional priority** (MR Credit 5.1: Regional Materials: 10 % Extracted, Processed and manufactured regionally)]	Ene 5–Low or zero carbon technologies – **Transport:** – **Water**: Wat 1–Water consumption Wat 2–Water Meter – **Materials**: – **Waste**: Wst 3–Storage of ecyclable waste – **Land Use + Ecology**: LE 4–Mitigating ecological impact – **Pollution** – **Innovation**

responsibilities and social equity. Business organisations need to adopt practices and behaviours that fully appreciate and respect that achieving sustainability requires us to live within the earth's capacity to provide materials for our activities and its ability to absorb the waste and pollution that these activities generate. Research, development and implementing product, manufacturing and construction eco-efficiency are required in industries to reduce waste and eliminate toxins in ways that do not stifle innovation. Joined-up thinking fostered by cross-disciplinary professional activities is of crucial significance for design quality improvements in infrastructures. A culture change in societies, communities and their people is also essential, allowing a meaningful engagement in the procurement, management and design of physical environments that matches habits and expectations.

Individually, each of the case studies indicates the key drivers of strategies based on integrating sustainability and evidence-based design. Some of the drivers are unique to the peculiar circumstances and context of the project. Each case study shows mechanisms which if applied are capable of embedding sustainability and evidence-based design in working practices which improve effectiveness and efficiency to deliver positive staff and patient health outcomes.

Houghton-Le-Spring Primary Care Centre's aims and objectives (extend the range of services available to patients; bring care nearer to where patients live and work; provide a catalyst for service modernisation; facilitate reconfiguration of service delivery models; provide opportunities for partnership working around health promotion; and create 'nodes' of services to reinforce communities) validate the architects' 10 guiding principles for sustainable healthcare buildings which include the creation of a quality internal environment that supports the health and wellbeing of user.

Acknowledging the link between the physical environment and patient and staff outcomes, the US New Parkland Hospital design team implemented a strategy based on integrating sustainability and evidence-based design translating the project vision into a meaningful and financially sound design and construction plan. From the outset, proven evidence-based strategies and corresponding interventions are identified to improve patient safety and outcomes, staff efficiency and effectiveness, increase patient, family, and staff satisfaction while accommodating today's best practices, with flexibility to adapt to the future. Sustainability is implemented and is evident through LEED™ registration + commitment and through the use green building methods and energy sources, as well as environment-friendly building materials. Proven strategies and associated design interventions are also supported by an appropriate evidence-based design process.

Implementation of the approach that integrates sustainability and evidence-based design is apparent in that The New University Hospital, Aarhus, Denmark, is modelled after an existing Danish town, Ribe, and therefore seeks to draw from and repeat successes of the past. This involves recognising the importance of a spatial organisational structure rooted in an urban hierarchy of neighbourhoods, streets and squares that provide a basis for the development of a diverse, dynamic and green urban area. The traditional town is therefore a conceptual starting point or a mechanism for organising the accommodation and its diverse functions. The hospital is not merely a construction project and catalyst for growth for a diverse and dynamic 'green' urban area but also a cultural project, involving the arts and sciences. The intention is that the hospital functions as both a university hospital, a regional centre and a treatment facility for citizens of the region. With the development of "The Healing Wheel of the Environment" as a foundation for planning the entire hospital project, The New University Hospital, Aarhus recognises the importance of evidence-based design.

First People's Hospital of Shunde District, Foshan is an AIA International award-winning Chinese hospital centred on evidence-based design principles as well as operational, behavioural and cultural concepts. Cultural and procedural expectations are factored into evidence-based design drivers for the schematic design for this hospital. Healthcare delivery systems and family involvement ensure a different interpretation to the 'evidence-based' solutions, which are often applied to hospitals in the USA. An 'inside-out' approach brings the human element into the design with application of brain, body and building science in the architectural or design process. Combined with an 'outside-in' approach, the human element is integrated in planning, programming and design development that also takes account of green sustainable goals. The designation of the project as a pilot sustainable hospital in China allows exploration of sustainable technologies for future hospitals. The design goal is to translate advanced Western healthcare ideas to accommodate Chinese local practices, creating an innovative healing environment. The fusing and respecting of the traditional medical practices in China and improving on functionality, minimising errors, maximising productivity and incorporating sustainability while providing services for up to 1,500 resident patients and 6,000 outpatients a day are the essentials of integrating design for sustainability and evidence-based design principles.

Key design principles for the integrated sustainability and evidence-based design approach within the Glenside Campus Re-development, Adelaide, Australia, are as follows:

- a place of refuge, safety, security and healing,
- demystification, destigmatisation, autonomy and integration,
- high standard of aesthetic quality and park-like settings,
- accommodation of diversity,
- ecological sustainability incorporating bio-retention and overland swales as well as rain water garden.

The modern healthcare facility provides specialist services for mental health, drug and alcohol care within the context of destigmatising the existing Victorian asylum dating back to 1836. Glenside Campus Re-development is notable because of its aspirations to create a benchmark for mental healthcare facility in Australia that also has appropriate international credentials in terms of evidence-based design coupled with ecological sustainability. The intention is that the benchmark for sustainability is in terms of real performance as opposed to the theoretical star ratings or scoring of points.

The trend of 'seeing green' is on a global scale with certain countries at the forefront of converting to eco-friendly building design and construction. In Asian and European countries, the high-energy demands have been an important driver towards going green. The case studies have been crucial in identifying emerging issues starting with the problem of definitions of "Evidence" and "Sustainability" but including the debates surrounding several themes: Centralisation vs. Decentralisation, the nature of Public vs. Private Sector Involvement, National vs. International Standards, Prescription vs. Performance Standards and Self-assessment vs. Independent Verification.

The term "evidence" is used as by Lawson and Phiri 2003, Ulrich et al. (2008) and Hamilton KD (2008) and refers to data collection and structuring that largely derives and follows rigours of science, while sustainability refers to both sustainable building and sustainable building-in-use. Four facets of sustainable development are environmental, cultural, social and economic.

Centralisation versus decentralisation has been an important driver, especially in terms of the necessary and vital development work for ensemble of healthcare guidance and tools. However, the appropriateness of building regulatory strategies and structures is increasingly under question with many standard regulatory systems becoming outdated, bureaucratic and inefficient to operate. Centralisation's major advantages are government sponsorship and authority afforded to the ensemble of guidance including ability to reflect healthcare policies of the government of the day, while disadvantages are competing for funding with other demands.

The balance between public vs. private sector involvement is another issue when determining who has the responsibility of developing and keeping healthcare guidance and tools fresh. Private sector involvement is typically driven by the need to make a profit, whereas public sector involvement may be more concerned with social and economic benefits, for example provision of healthcare services, which are not economically viable but are necessary because they are socially beneficial. In many ways, public sector involvement is a safety net or is the last resort should private sector involvement be a failure.

Advantages for an individual country developing its own ensemble of guidance and tools include the ability to relate these to that country's legislation, healthcare policies and peculiar circumstances. This is one of the key drivers for China to develop its own ensemble of healthcare guidance and tools, for example via customisation of existing material from abroad. However, a decision for the country to develop and maintain its on guidance system and tools can be costly and requires ongoing investment in intellectual expertise, governance and competencies. As a viable alternative option, pooling of financial and intellectual resources to produce guidance/norms that remain current and technically sound can be carried by utilising International Standards Organisations.

A major challenge in developing core healthcare standards is determining the balance between prescriptive and performance requirements. Prescriptive requirements spell out exactly how something is to be done, and performance requirements merely outline what the required level of performance is leaving it up to the designers how this is achieved offering opportunities for innovation while reducing the regulatory burden. The problem is that performance-based building standards are principally concerned with health, safety and amenity issues for building occupants driven by compliance with 'minimum threshold' quantitative measures rather than overall design quality improvement, especially as indicated by qualitative factors for achieving excellence.

An emerging issue of how healthcare guidance and design tools should be implemented in practice and by whom relates to the definition of "evidence". Self-assessment, self-assurance and self-regulation approaches are often adopted in practice as a way of passing on all responsibilities for healthcare standards from the top down to a local level. Devolving responsibilities for healthcare planning standards, building regulations or design codes helps to reduce costs for development, updates and ensuring the accuracy of the information. Nonetheless, assurance systems must always be more self-motivated, innovative, resilient and adaptive while not relying on policy targets and lagging performance compliance.

Bridging the gap between aspirations and results is important. Typically, healthcare building projects generally start with good intentions, for example, in terms of their carbon footprint and energy efficiency. However, results often fall short of the original ambitions and traditional procurement practices are not delivering fast enough on carbon reduction. Economic viability and operational risk are not regarded by stakeholders as the critical barriers to low carbon innovation. The key problem appears to be that low carbon policies have not yet influenced wholesale changes in procurement culture. In particular, there is a lack of low carbon innovation leadership from both the healthcare sector and the design and construction supply chain.

The brief takes the view that recognising and addressing all these emerging issues has an important bearing on the development of design for sustainability and evidence-based design as science. Sustainable healthcare facilities using evidence-based design principles and corresponding interventions are in a business to heal people, not make them any sicker. When providers of hospitals and healthcare facilities decide to choose and focus on sustainability coupled with evidence-based design, they are in essence deciding to do what is right for the long term in support of patients, staff and their healthcare environment in a way that can be demonstrated using the rigours of science. The brief is helpful in showcasing healthcare projects that indicate the state of development of the interrelationship between design for sustainability and evidence-based design. It concludes accepting that applying design for sustainability coupled or integrated with evidence-based design is even more in infancy and under development as an emerging science than evidence-based design on its own.

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