Streamer
European research on energy-efficient healthcare districts

# D3.1 Building-oriented EeB KPIs of newly designed and retrofitted buildings

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**Streamer - Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems.**
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# D3.1

## Building-orientated EeB KPIs of newly designed and retrofitted buildings

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### Colophon



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# Publishable executive summary

The main objective of the Streamer project is to create a BIM based tool that focuses on and reduces by 50% the energy used in the built environment of healthcare estates/districts throughout Europe. The processes of design, construction and operation and maintenance are the key activities that underpin the success of such an ambitious objective. Whether a single project option, multiple options, new build or refurbishment, the approach to save energy should be the same and that is that there should be indicative performance criteria to support the successful direction of the process. In this report we have considered the potential for saving energy within the existing estate and developed 3 key performance indicators that will offer that direction.

The most important KPI will be that of Energy Performance and Efficiency. This uses a "Layers" approach which considers that an acute hospital will consist of four definable usage types namely Hot Floor, Hotel, Office and Industry. They are used to identify the occupant usage characteristics which can, with the aid of a thermal model, help us understand the energy that can be used in each layer. An initial energy target can then be applied to each layer to enable the design process to progress within the parameters of the energy target. The areas of each layer combined with the energy modeled through the design process will offer the user the total theoretical energy use for the building. Comparison with existing published targets and also the development of a data base of targets for similar layers will be an on-going confirmation of the approach. Once the building is in operation, the monitoring of the energy use will be on-going and will undergo comparison with the original design targets. If there is a gap between the actual energy used and the designed energy target, then the operation and maintenance of the facility can be reviewed. Also, when any future remedial work is carried out on the facility which includes change of use, façade or building engineering systems replacement, the target can be reviewed as appropriate to align with any reduction or increase in energy use.

The second KPI is that of Financial Analysis based on Whole Life Costing. This uses the concept of discounted cash flow or simple payback depending on the complexity, scale and timing of the project analysis. No healthcare project is free from the constraints of the financial budgeting but more often than not the financial analysis is based on lowest first (capital) cost with little regard for the on-going life cycle costs of the facility. Such is the importance of energy use and the subsequent impact of carbon emissions that a whole life costing approach must be taken seriously if we are to apply any long term energy reduction strategies into the healthcare estate/district.

The third and final KPI is Quality of the Environment and Operational Efficiency. The expectation of the populations of all countries towards the delivery of healthcare continues to increase. The need to recruit and to retain staff continues to challenge the owners and operators of healthcare facilities. The benefits of reducing energy use which is the key requirement of Streamer, is largely invisible to those looking for high quality healthcare environments and hence it is essential that energy reductions should be delivered with due regard to the quality of the facility. This has been encapsulated in the term "therapeutic environment". This is an attempt to define some key objectives that if employed within the preliminary design process will satisfy both the quality ambitions of the patients, carers and staff alike without having too much of an adverse impact on the energy reduction strategy.

Difficulties can arise when attempting to impose a set of KPI's on existing processes. The first is that there has to be due regard to the current standards that are in place throughout the EU and within individual member countries. However, we believe that the three KPI's selected will work in support of any countries current standards and guides. The objectives to success defined in the report are in the main taken from existing guidance that is currently in use. Secondly, the boundary of the EU involves different climates which need to be accommodated within the development of and the adherence to the energy target development and compliance. We believe that the inclusion of climate factors within the energy modeling process will enable comparisons across climates to be made in a sensible fashion. Thirdly, although we tend to default to a "new build" direction when considering energy reduction, the Streamer project must also focus on refurbishments within the healthcare estate/district. In fact it could be argued that the main focus of energy reduction in the future will be the existing building stock. It is important therefore to be able to gauge the potential to save energy and we can do this by considering the age of the building(s) and the construction standards and thermal efficiency standards applicable at the time of design/construction. This presents itself as an age factor within the matrix of information that we will need when we consider the potential for energy reduction.

Finally, the development of these KPI's is only one part of the Streamer process but hopefully one that will have a unifying effect on the project as a whole. It is believed that the KPI's as they are presented are not so onerous as to be a burden and hence ignored by hospital owners and their design teams, but will be a flexible platform in which to easily compare and contrast energy reducing solutions for new and existing building on the healthcare estate/district.

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# 1. Introduction

The aim of the STREAMER project is to offer a BIM driven process that enables owners, operators and designers of healthcare facilities, to effectively prioritize their options and enable energy efficient developments (both new build and refurbishments) to take place within the estate/district, that will make a positive contribution to the reduction of energy. A further benefit will be to enable hospital owners and operators through the BIM models the ability to consider the potential for energy reduction across the site if “best practice” energy interventions were to be incorporated.

# 2. The development of a KPI

Many organisations use KPI’s to measure the performance of their business. These KPIs represent a set of measures focusing on those aspects of organisational performance that are the most critical for the current and future success of the organisation. As the STREAMER project is based on the need to significantly reduce energy use within the hospital estate/district we need to select KPI’s that inform owners on how to make dramatic increases in energy performance.

# 3. A balanced approach to the development of an energy based KPI

An important consideration when we prioritise options specifically to improve the energy utilization should be the unintended consequences that can be produced. Some essential consequences to consider include the quality of the environment being produced. This can be directly aligned to occupant comfort (patients, staff and visitors) Also, the capital cost of the measures that are to be put into place as well as the flexibility (particularly important in new build projects) that is being integrated into the estate/district. There is little use in reducing the energy if the comfort conditions that are created are not supportive of a high level of staff performance or patient well-being. Similarly when we prioritise our options we need to ensure that the energy we are saving comes at a reasonable level of capital cost. Therefore by including both financial and qualitative measures we need to apply a cost benefit analysis approach or similar analysis tool. This balanced approach, originally developed by Kaplan and Norton’s balanced scorecard and which has been supplemented by Parameter (Ref 1) as shown in Figure 1 is an ideal explanation of the approach.

| Financial | Customer Focus | Environment / Community |
|---|---|---|
| Utilization of assets, optimization of working capital | Increase customer satisfaction, targeting customers who generate the most profit | Supporting local businesses', linking with future employees, community leadership |
| **Internal Process** | **Employee Satisfaction** | **Learning and Growth** |
| Delivery in full on time, optimising technology, effective relationships with key stakeholders | Positive company culture, retention of key staff, increased recognition | Empowerment, increasing expertise and adaptability |

Figure 1 Six perspective Balanced Scorecard

Although the wording within the balanced scorecard in Figure 1 may not be completely focussed on the use of energy in the healthcare district/estate we can amend the scorecard to support the aims of the STREAMER project. Figure 2 offers a possible amended scorecard that supports the aims of the STREAMER project. A major change is the Environment/Community section which highlights the reduction in energy use and carbon emissions. Significantly, energy is embedded in 5 of the 6 sections which is the key focus of the STREAMER project.

| Financial | Customer Focus | Environment / Community |
|---|---|---|
| Utilization of assets, optimization of working capital directed towards energy efficiency. | Developing spaces of wellbeing to improve patient satisfaction through care and effective recovery | Reducing the use of energy and carbon emissions within the district |
| **Internal Process** | **Employee Satisfaction** | **Learning and Growth** |
| Empower staff to deliver low energy solutions, optimising technology, improve efficient working practices | Create low energy organisational culture, retention of staff through quality working environments | Increasing expertise in energy issues, creating flexible and adaptability facilities for future healthcare needs. |

Figure 2 Streamer focused Six perspective Balanced Scorecard

# 4. Understanding the potential to reduce energy

In order to develop an energy driven KPI it is important to consider the areas where energy can be saved i.e. where is the potential to be found within the built environment component of the healthcare estate/district to save energy and reduce carbon emissions?  An important piece of work was carried out by the Sustainable Development Unit which is aligned to the UK NHS (Ref 2) to calculate the carbon footprint of the NHS in England. This helps in considering the energy saving potential we have within the campus/district. Figure 3 shows the breakdown of the energy use in the NHS in England.

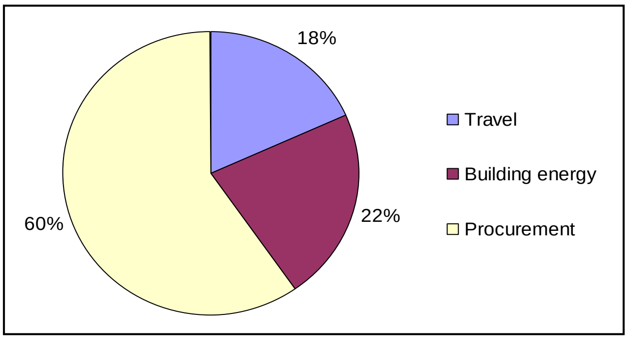


Figure 3 Energy use and Carbon foot-printing of NHS England (2004): 18.6MtCO2

The model developed for the 3 sectors of energy use are based on the following:

**Procurement** - Goods and services purchased by NHS England (excluding energy and travel)
**Building energy** - Heating, hot water, electricity consumption and cooling
**Travel** - Movement of people (i.e. patients, visitors and staff).

Although based on a single country profile, we can probably assume that there will be a close correlation between this model and that which could be applied to many other countries in Europe and particularly those involved in the STREAMER project. This assumption is based on the general provision, standards and activity of acute care in the participating countries.

The next step is to consider from a general point of view where the energy is expended in an acute district/campus setting. As with the overall energy use shown in Figure 3, we could assume that the mix of building age and use is reasonably consistent across the EU. Figure 4 shows a breakdown of the system loads for an acute new build installation.

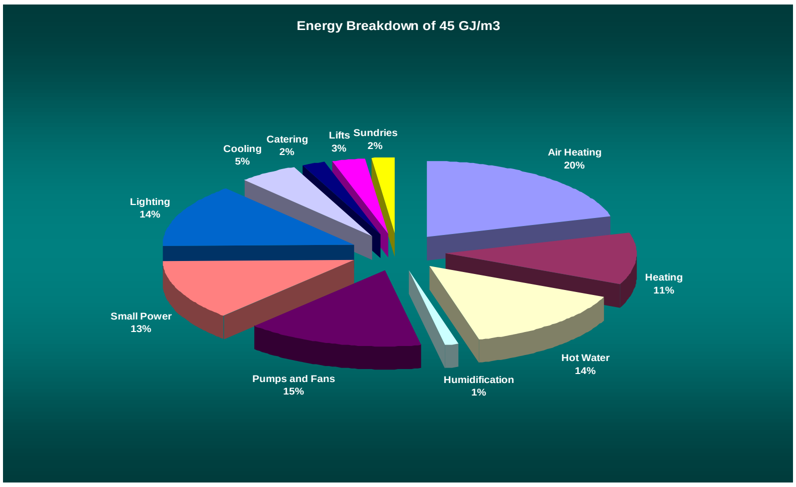

Figure 4 Acute hospital energy breakdown – May 20th 2008

The weakness in extrapolating this data is the specific climate differences between countries. This will have an obvious impact on the heating and cooling loads when we consider the climate of Sweden in the north, Italy in the south, Poland in the east and the UK in the west. This climate difference will need to be considered as part of the individual energy modeling process at project level.

# 5. Overriding Streamer principals that can underpin a KPI approach to energy use

## 5.1 Design effectiveness

In 1997 the UK Design Council stated that "by the time a building is completed up to 90% of its life cycle economic and ecological costs have been made inevitable. This is still true 17 years later. In order to create energy efficient facilities the design solutions remain the critical success factor as this process underpins the energy efficient efforts of the construction and operational and maintenance processes.

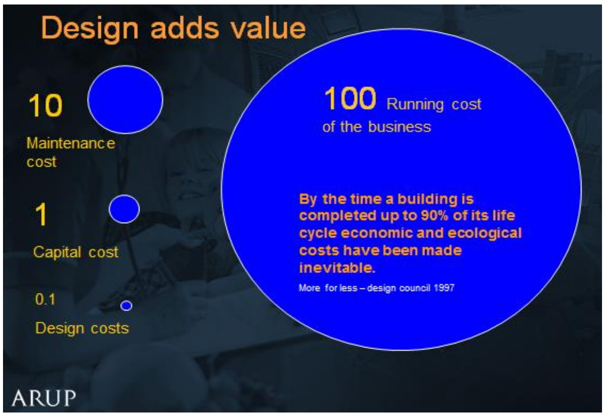


Figure 5 More for less – UK Design Council report 1995

Standards are important to the process of effective design and there are three likely opportunities for projects to engage with standards in Europe. They are the European Standards (Directive 2002/91), the appropriate healthcare standards for the individual country (BREEAM (Ref7), LEED, Gold Starr etc.) and the appropriate local (country) operator standards and practices. It is important to recognize that in order to reduce the energy use across the building stock within the estate/district in a holistic and long lasting way the three processes of design, construction and operation all have their part to play. Some examples of the considerations that need to be made during each of the processes are shown below.

1. **Primary energy source and capacity**. *A new major development will require an infrastructure capacity survey. This will include any changes in the major centers of energy loads and the manner in which distribution occurs. A review of the primary energy loads and whether any site generation can be achieved should be considered at the earliest time during the planning of a major development and factored into the business plan.*

2. **Patient and staff safety by satisfying clinical requirements**. *Air volume flow rates, clean filtered air and air pressure differences across different spaces are key requirements in the clinical safety process as is domestic water distribution and temperature. The requirement to create low energy facilities must not compromise the safety of staff and patients.*

3. **Operational usage.** *An understanding in the manner in which staff use and operate individual facilities is essential in providing the correct level of user/automated control within different facilities. Also the periods of occupation are vital to understanding the energy patterns within each department/facility.*

4. **Spatial capacity**. *Acute healthcare facilities are forever changing and hence the ability to add both electrical and mechanical systems into the building is critical to future effective working as change is introduced. Good design requires an allowance for space within major horizontal and vertical distribution routes to be built into the design solutions.*

5. **Renewable energy opportunities.** *The ability to review the opportunities to increase the renewable energy generation strategy is of fundamental importance in the challenge to reduce carbon emissions. Capital and revenue cost implications as well as resilience are of particular importance in the development of a renewable strategy.*

6. **System resilience against short term weather patterns and climate change.** *The changing climate is having an increasing effect on the acute healthcare facility. Not only is the hospital historically a "safe haven" for the population but it also a 24/7 environment that is the first line of defence during major weather instability such as prolonged high temperatures, high winds and flooding. The design of facilities must take into account the system resilience required to enable operational effectiveness during such events.*

7. **Building envelope efficiency including natural ventilation strategy.** *This represents a key area that can reduce energy in mechanical ventilation systems and lighting systems. The design of the façade to maximise natural daylight and introduce natural ventilation also has other therapeutic benefits and hence should be considered as an essential design approach whenever clinical activity allows.*

8. **Plant room capacity to ensure effective maintenance can be carried out.** *The space required for plant has increased over the years with the increase in the amount of air changes and the cooling requirement for many of the areas within the acute hospital district/campus. There is also a requirement to distribute plant into defined systems such as incoming infrastructure services and metering, centralised hot water generation, local secondary water services, water storage, local ventilation plant and cooling plant as well as medical gases etc. Adequate space must be included in the concept design to ensure that plant can be adequately maintained and replaced.*

9. **System distribution spatial adequacy**. *Major horizontal and vertical distribution routes must be adequately sized to ensure that appropriate maintenance can be carried at all times with minimum disruption to the on-going clinical functions. Access to control dampers and regulating valves should be within corridor areas and not clinical areas. Distribution ductwork and pipework inspection, cleaning and control functions should be via accessible corridor risers and accessible corridor ceilings*

10. **System reliability against failure**. *The concept design should reflect the need to provide a plant strategy that allows for resilience through run and standby/duplication of plant, auto-changeover systems, locally held spares and easily acquired major replacement. Bespoke equipment should be a*

*last resort within the plant strategy. A high quality plant procurement strategy should be adopted given the 24/7 nature of the much of the estate.*

11. **Appropriate systems aligned to effective zoning**. *Facilities with differing occupation times housed within the same building, differing clinical activity and acuity as well as departments with different filtration and pressurisation regimes should be considered as the basis for a ventilation plant zoning strategy. The same consideration should be applied for water systems where duplex systems to allow for the isolation of water tanks and heat exchangers to allow for cleaning and maintenance to be carried out without disrupting the operational services are essential.*

12. **Correct plant sizing.** *Energy can be lost through oversizing plant however it is also important to recognise that there is an allowance to be made to allow effective commissioning to be carried out i.e. moving the design from a theoretical base to a fully operation set of systems, as well as allowances for future additions to the facility. A clear strategy should be adopted for this short term and long term flexibility to occur whilst ensuring that the final operating efficiency in all conditions is maximised.*

13. **Ensure there is a clear understanding of the controls strategy.** *The controls strategy for a clinical facility can either be stand alone or connected into the site wide network for monitoring only or control and monitoring. It is essential to ensure that for the on-going reduction in energy use, there is adequate sensing, monitoring and controlling devices installed within the distribution system.*

14. **BMS design and Commissioning planning**. *It is important to ensure that regular reviewing of the commissioning process is carried out and seen to be an integral part of the design process. A comprehensive commissioning plan should be developed that addresses the monitoring of the energy use during the early start-up of the facility as well as the on-going energy reduction strategy. The main control functions will likely be managed through a BMS system. This system may sense, monitor, control and present data in a manner that can support an energy reduction strategy.*

15. **Post occupancy evaluation and feedback.** *Continuous staff and patient feedback is an essential tool when considering the efficient use of energy in a healthcare facility as well as the quality of space that has been provided as part of the design process. This feedback will support future design initiatives and encourage the adoption of energy efficiency within the facility and eventually* campus/district wide.

16. **The project design approach being based on whole life cycle costing**. *When considering the priorities for a new build, refurbishments or a mixture of both types as part of campus/district wide development strategy. A financial consideration must be a key component to enable decisions to be made on a cost/benefit basis. A preferred approach should be a whole like costing approach where the capital cost of the works is considered in tandem with the operational running costs of the project, particularly the energy and maintenance costs.*

## 5.2 Construction Effectiveness

The construction effectiveness as it relates to energy will be developed as part of the pre-qualification and tendering documentation. As with design there are three opportunities for the engagement of standards. They are the European Standards (Directive 2002/91), the appropriate healthcare standards for the individual country and the contractors proven standards and practices. Some examples of considerations that need to be made by the contractor when considering the impact on the energy use in a healthcare environment involve the following:

1. **The selection of system components and of construction materials.** *This must be considered in detail to ensure that low energy approach is the ultimate goal for the project whether is major or minor works. This is particularly significant where the components are contractor based design elements and selection through a "performance" based process is required: where alternatives are allowed to be selected: where the project is a contractor led design and build contract.*
2. **The selection of the envelope with particular emphasis on leakage**. *This is key to a low energy approach given that the envelope is the moderator to the micro climate. Pressure testing at the works to ensure compliance with specific standards of the façade elements to ensure effective sealing is essential. The use of thermal imaging and on-site pressure testing (where practical) can be used to confirm whether construction effectiveness has been achieved.*
3. **The closing of all construction connections.** *All points where construction connections are created within a building are to be sealed against air leakage to prevent energy loss as well as preventing vector borne infection. This is important when constructing basements, lift shafts and plant room and major riser connections. The same care must be adopted to eliminate thermal bridging.*
4. **A high standard and planned commissioning process.** *The highest standard of commissioning is essential in a low energy strategy for healthcare environments. The high air flow rates, high efficiency filtration, pressure gradients and the switching to reduced volume flow rates are all components that will influence the energy use in the system. Commissioning programmes must be developed during the design stage and followed through after construction. As a healthcare facility is usually a 24/7 environment any further major commissioning after project handover becomes an unnecessary intrusion on the operational effectiveness of the facility.*
5. **Operation and maintenance manuals to be developed**. *Detailed, comprehensive and well-presented information must be available to those responsible for operation and maintenance covering the exact plant installed, the design operating parameters and maintenance instructions.*

### 5.3 Maintenance and operational effectiveness

The maintenance and operational effectiveness will be influenced by the best practice guidance generated or adopted by the specific country as well as the local operator's standards and proven practices. Some examples of considerations that need to be made by the commissioning agents and operators that will influence the energy used in the facility include the following:

1. **Maintaining a safe and healthy operational environment**. *This must be the primary requirement and adhered to at all times for the safety of patients, staff and visitors. Many countries will have their own requirements set out in law such as the Health and Safety at Work Act in the UK. In the EU the Health and Safety Framework Directive (89/391/EEC) is the key piece of legislation for the protection of employees. This directive ensures protection for employees at work by using preventative measures that protects against accidents and occupational diseases.*

2. **Operation and maintenance manuals to be kept up to date**. *Detailed, comprehensive and well-presented information must be available to those responsible for the operating and maintenance of the facility. The documents must be kept up to date as changes occur over time in the engineering systems of the facility. Carrying out maintenance on out of date documentation can be dangerous for patients and staff, it can increase the use of energy and also affect the clinical operational effectiveness of the facility.*

3. **The Integration of a risk management system.** *In a complex and life threatening environment such as a healthcare facility it is essential that a process such as "failure modes, effects and criticality analysis" (FMECA) is in place to establish the risks of failure.*

4. **Comprehensive maintenance policy.** *This policy will determine the organisation of a maintenance management system that will in part ensure that life-saving systems are correctly and safely maintained at regular intervals and that energy reduction is part of the maintenance agenda.*

5. **Ensure maintenance audits are carried out to confirm maintenance effectiveness**. *When third party maintenance organisations are used e.g. on specialist pieces of equipment or specialist systems it is important to ensure compliance with the standards that have been set down in the maintenance policy document. This includes the inspection of maintenance log books.*

6. **Utilize the BMS functions to collect and present data in a meaningful way.** *A comprehensive BMS system is now the standard requirement of a healthcare district. It performs the overall control and monitoring functions for the majority of the engineering plant and systems within buildings and includes the site wide monitoring and potentially the alarm requirements. Importantly, the BMS system commissioning and maintenance is carried out by the manufacturers and hence routine maintenance should be planned as well as periodic re-commissioning to ensure that energy management is optimised particularly after the refurbishment of a facility. Of particular importance is the regular and consistent reporting of energy use to ensure a record is kept of the impact of building improvements on energy. This can then act as a benchmark for the future.*

7. **Carry out plant replacement efficiently to prevent backlog maintenance.** *A planned maintenance schedule should be developed to ensure that all maintenance activities are well thought through and carried out on time. Should this not be the case then maintenance liabilities can occur, leading to a significant maintenance backlog. This could then have the possible outcome of plant and system breakdown, premature plant failure, reduced occupant comfort, a reduction in clinical operational performance and higher energy use.*

8. **Continuing improvement in energy reduction**. *Operation and maintenances personnel are in an ideal position to monitor report and upgrade plant and systems during replacement periods or planned building refurbishments. This must be done with a view to including the latest energy efficient products, plant and systems. This will ensure that energy is reduced as a priority at every opportunity. Benchmarking historic data against proposed installations can assist with the expectations of energy use and the associated financial savings. The manner in which the necessary capital cost for energy saving measures is justified in the business plan will undoubtedly be based on the savings that can be achieved through the energy reduction measures put into place.*

### 5.4 Refurbishment considerations

The above lists of considerations are primarily related to a new build project. However, much the same consideration should be included in a refurbishment project. The ability of Streamer to be used in the development of refurbishment projects is essential. The existing healthcare estates within Europe will have a number of generations of building types. Each generation will have their own weaknesses in terms of the modern demands for energy use, flexibility and operational efficiency. It is therefore likely that in the coming years there will be a major focus on the development of the existing building stock on the healthcare estate/district. The scope of a refurbishment project can vary in size from a simple redecoration to a complex re-servicing, plant renewal and façade replacement. A typical list of refurbishment projects is included below, each one with a varying scope. It is for the hospital operator to decide the relevance of the project to the suggested KPI's discussed later in the section:

1. Single phase whilst in occupation – redecoration
2. Single phase with decant – back to original use
3. Single phase with decant – change of use
4. Refurbished in a phased manner whilst in occupation
5. Replacement building engineering systems – space and distribution complexity
6. Resilience to system failure and climate change
7. Structural integrity 1 – re-cladding options
8. Structural integrity 2 – extended floor plate, en-suite pods fitted
9. Non-viable spatial solution for future models of care – change of use or demolish

# 6. Proposed STREAMER KPI's

The focus on energy is the prime consideration for the STREAMER project. However, as can be seen in Figure 2 a balanced approach should be integrated into the process. It is therefore proposed that there are 3 KPI's considered for the project as shown below. They cover energy, finance and customer and staff satisfaction.

### 6.1 Energy Performance and Efficiency

a. Reduced primary energy and carbon emission
b. Energy and carbon targets within country regulations
c. Energy and carbon targets within EU regulations
d. Energy and carbon targets developed as industry benchmarks
e. Energy and carbon targets developed through international best practice
f. Passive system integration
g. Active system integration
h. Use of renewable technology
i. Resilience risk considered and managed

### 6.2 Financial analysis based in Whole Life Costing

j. Whole life costing methodology

### 6.3 Quality of the Environment & Operational Efficiency

k. Staff satisfaction

l. Patient satisfaction

m. Visitor satisfaction

n. Connectivity, adjacency, access and flexibility

o. Improved clinical outcomes

p. Safety and security

# 7. Practical approach to achieve Streamer KPI's compliance

### 7.1 The energy model

Central to the successful compliance will be the construction of an energy model for each building option to be considered. The model will be a dynamic model and will consist of a number of parameters set down below in Figure 6. There are a number of software packages available to carry out a dynamic modeling calculation of this type. For this section the model has been based on IES "Virtual Environment".

| Category | Item |
|---|---|
| **Building Geometry** | Floor plans<br>Elevations<br>Sections<br>External shading<br>Building context (i.e. adjacent buildings/terrain) |
| **Construction Materials** | Walls<br>Roofs<br>Floors<br>Windows<br>Ceilings<br>Doors |
| **Air Permeability** | Test certificate<br>Or target air permeability |
| **HVAC System Information** | System efficiencies<br>Usage profiles |
| **Internal Configuration** | Number of occupants |

| | |
|---|---|
| | Installed lighting load<br>Small power/equipment load<br>DHW demand/usage<br>Usage profiles |

Figure 6 Energy model input data

From this input data an annual energy consumption figure can be calculated for each option and this becomes a key piece of data in the project option evaluation. This information can be compared with existing benchmarked data or compared against a set energy target. The use of a target is considered as a preferred route for the next stage of the development because the target will inform the appraisal process as to the likely energy use of the building and will also be an indication of compliance with the energy saving focus of STREAMER.

## 7.2 The development of energy targets

Likely targets that we suggest could be used in the first instance are those that are currently in use for healthcare facilities in the UK and which were developed by the NHS and published in their Health Technical Memorandum 07.02 (Ref 3). These targets have been derived from benchmarked data taken from a large number of healthcare facilities and therefore have an analytical basis which can be considered as a reasonable starting position. Figure 7 below reproduces the targets taken from the HTM 07.02. It should be stressed that the targets must be continually reviewed and reduced to create a challenging environment for both designers and manufacturers who will need to continue to develop energy reducing systems, materials and products.

| Site Typology | GJ/100m3 |
|---|---|
| | New/Refurbishments |
| **Teaching and specialist hospitals** | <55 |
| **General acute hospitals** | <52 |
| **Community and mental health in-patient facilities** | <40 |
| **GP surgeries** | <36 |
| **Health centres and clinics** | <25 |

Figure 7 NHS Targets from 35-55 GJ/100m3

### 7.3 Practical use of the energy model

In order to develop our understanding of the energy targets in the current design environment we have benchmarked a number of recently designed projects which can be compared against the quoted targets. Figures 8a, 8b and 8c present those projects with the energy data and also attempts to define the energy used by layers i.e. hot floor, hotel, office and industry (see D1.1 for layer definitions). Energy consumption data has been extracted from the detailed dynamic simulation models created during the design process of the projects. A total of 3 projects have been selected as follows:

Modeled data

- Admin – Cochrane Building
  - An office/educational development on a healthcare site in the UK completed in 2012. It has been designed to incorporate many passive design measures and includes a substantial green roof. It is predominantly naturally ventilated and designed to improve minimum building regulation standards by 20% (achieving BREEAM Excellent).

- Hotel – CAMHS
  - A care facility in the UK for young people with eating disorders. The building consists of mainly residential bedrooms with en-suites, along with a sports hall, classrooms and office areas. The building was designed to be naturally ventilated and have a strong passive design. Construction was completed in 2010.

- Hot Floor – Altnagelvin Endoscopy Unit
  - An addition to an existing hospital in the UK, the endoscopy unit consists of 3 treatment rooms, with associated inpatient/outpatient areas. Most of the spaces are mechanically ventilated and cooled via a traditional chiller. Construction was completed in 2013.

Industry has been excluded from the model data as energy consumption tends to be related to the 'process' rather than the building, and it is therefore an unsuitable candidate for thermal modeling given that the equipment requirements are usually bespoke and full information on the equipment may not be known as the early stages of the design.

**Office**

| Admin – Cochrane Building | | | | | |
|---|---|---|---|---|---|
| **Activity "Layer"** | GJ/100m3 | kWh/m2 | Systems | GJ/100m3 | kWh/m2 |
| **Office** | 16.1 | 143.5 | Heating | 4.0 | 35.9 |
| **Hotel** | 0.0 | 0.0 | Cooling | 0.0 | 0.4 |
| **Hot Floor** | 55.2 | 490.7 | Auxiliary | 2.4 | 21.3 |

| | | | | | |
|---|---|---|---|---|---|
| **Industry** | 0.0 | 0.0 | Lighting | 0.4 | 3.8 |
| | | | DHW | 6.5 | 57.8 |
| | | | Equipment | 4.5 | 39.6 |
| **Average** | | | | 17.8 | 137.7 |

Figure 8a Calculated energy use for Office layer

**Hotel**

| **Hotel - CAMHS** | | | | | |
|---|---|---|---|---|---|
| **Activity “Layer”** | GJ/100m3 | kWh/m2 | Systems | GJ/100m3 | kWh/m2 |
| **Office** | 13.0 | 126.5 | Heating | 6.1 | 59.5 |
| **Hotel** | 21.3 | 207.5 | Cooling | 0.0 | 0.3 |
| **Hot Floor** | 0.0 | 0.0 | Auxiliary | 0.5 | 5.2 |
| **Industry** | 0.0 | 0.0 | Lighting | 3.3 | 32.5 |
| | | | DHW | 2.5 | 24.6 |
| | | | Equipment | 6.6 | 64.3 |
| **Average** | | | | 19.2 | 186.3 |

Figure 8b Calculated energy use for Hotel layer

**Hot Floor**

| **Hot Floor - Edoscopy** | | | | | |
|---|---|---|---|---|---|
| **Activity “Layer”** | GJ/100m3 | kWh/m2 | Systems | GJ/100m3 | kWh/m2 |
| **Office** | 11.0 | 106.7 | Heating | 6.2 | 59.8 |
| **Hotel** | 0.0 | 0.0 | Cooling | 1.3 | 12.8 |
| **Hot Floor** | 30.5 | 296.3 | Auxiliary | 2.2 | 21.5 |
| **Industry** | 0.0 | 0.0 | Lighting | 4.4 | 43.1 |
| | | | DHW | 3.5 | 34.4 |
| | | | Equipment | 9.8 | 95.0 |
| **Average** | | | | 27.4 | 266.7 |

Figure 8c Calculated energy use for Hot floor layer

**Rotherham Assessment – actual data**

The information below has been obtained by our Streamer partners at Rotherham Hospital and as such represents operational energy data for the 2013/14 financial year. Three examples of administrative (Office) areas and one hotel based facility has been considered and compared against the targets stated above. Figures 8d and 8e illustrate the actual energy usage figures.

| Building Name | Encode (GJ/100m3) | Total Energy |
|---|---|---|
| **Woodside (1990's)** | 25.2 | 178.7 |
| **Busy Bees Day Nursery (1980's)** | 57.3 | 405.8 |
| **Oakwood Lodge Security Centre (pre 1970's)** | 70.3 | 499.2 |

Figure 8d Actual energy use for of Admin Layer

It can be seen that the Oakwood lodge has a particularly poor performance. On investigation a potential explanation for its poor performance is the age of the building (pre 1970s) which has single glazing with timber frames. Additionally electrical demand may be high due to security equipment housed within the building. There would also need to be an emphasis on improving the Busy Bees day nursery which as a nursery would need higher internal temperatures and higher levels of natural ventilation as staff opens windows. If the facility has poor controls then the operational requirements and the environmental systems are working against each other and would need to be reviewed. Importantly, once an analysis is carried out a strategy for improvement can be put into place.

| Building Name | Encode (GJ/100m3) | Total Energy |
|---|---|---|
| **Oakwood Community Hospital (1990's)** | 59.8 | 423.9 |

Figure 8e Actual energy use for of Hotel Layer

Energy consumption at Oakwood is around the benchmark for both heating and cooling so performance is relatively good for a building of its age. The building is a rehabilitation care facility with 16 beds and the energy data reveals that consumption is mainly related to natural gas. Therefore investigation into additional insulation to improve the building fabric may be the best course of action in reducing carbon emissions.

### 7.4 Gas Consumption Reduction and building age factor

Since the early 1970's there has been significant effort to reduce the gas consumption of buildings through the legislation imposed by Building Regulations (in the UK) which has forced an improvement in the thermal efficiency of fabric. The age of the building and hence the imposed thermal efficiency at the time of construction must be considered when comparing the energy use of an existing building against current energy targets. It is also important to understand the generation and type of construction to make judgments' about the ability of the building to accept fabric improvements. We have therefore evaluated existing thermal modeling information to estimate the potential reduction in natural gas usage across various test years that align with improvements in building thermal efficiency. This enables us to estimate the potential reduction in energy of an existing building by considering the gas consumption changes against the time line below (Figure 9). We can create an "age factor" that relates the current energy usage to the energy that would have been used when the building was designed.

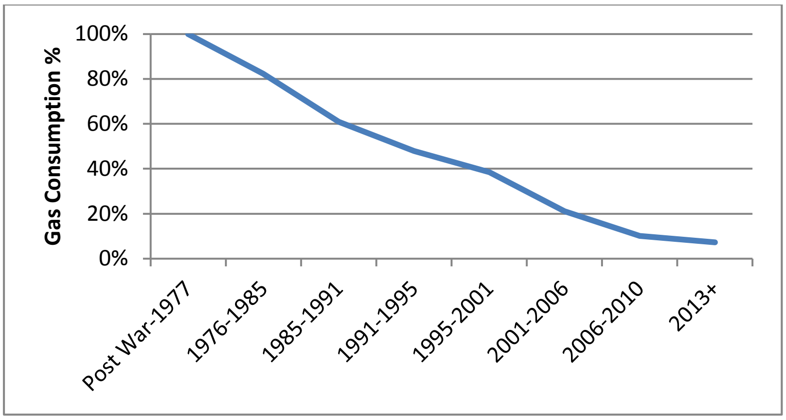


Figure 9 Energy efficiency trend based on gas consumption

As a test case if the Oakwood Security Lodge which is a 1970's building , was to have its fabric refurbished to match relatively modest upgraded standards (2001-2006 for example), then this could be as much as a 80% reduction in gas consumption.  This would be enough to reduce the annual energy consumption from the currently poor 70.3 GJ/100m³ to 34.1 GJ/100m³.

### 7.5 Climate factor

The energy model that is required as part of the Streamer energy reduction project must consider the different climates as this will influence the targets being developed.  We have therefore considered the following countries with associated climates as the basis for developing "climate factors": Sweden in the north, Poland in the east, Italy in the south and UK in the west. Figure 10 confirms the thermal behavior of the extremes of our climate boundary with Italy having higher cooling requirements and Sweden higher heating needs.

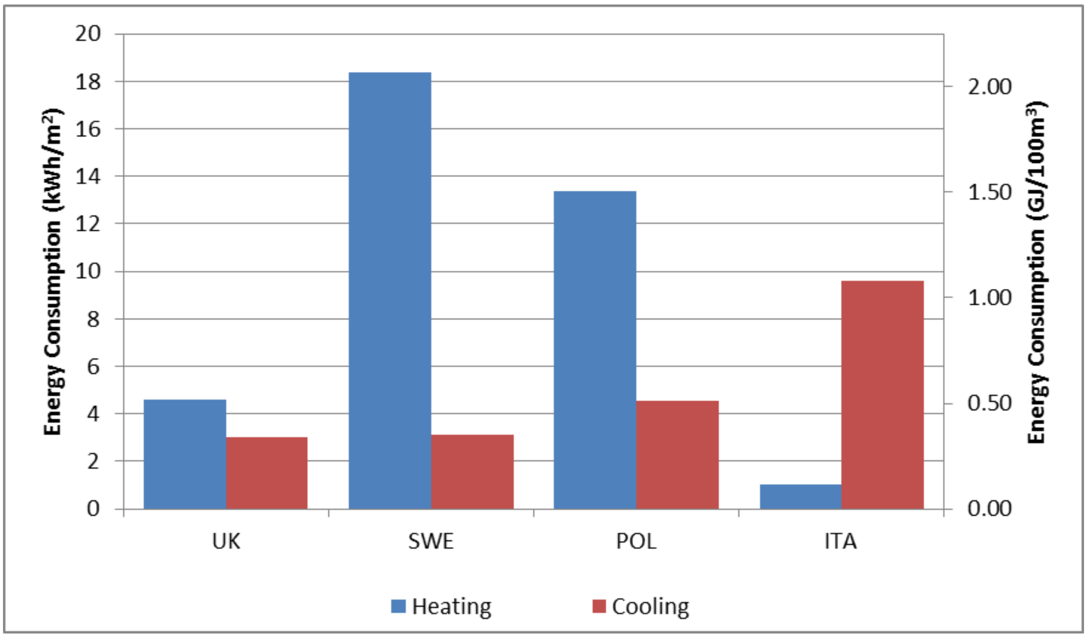


Figure 10 Climate factors and the relevant energy implications

When the energy model, energy target, building age and climate differences are taken into account we could consider the matrix in Figure 11 as a preliminary example of the manner in which the data may be represented for each project option.

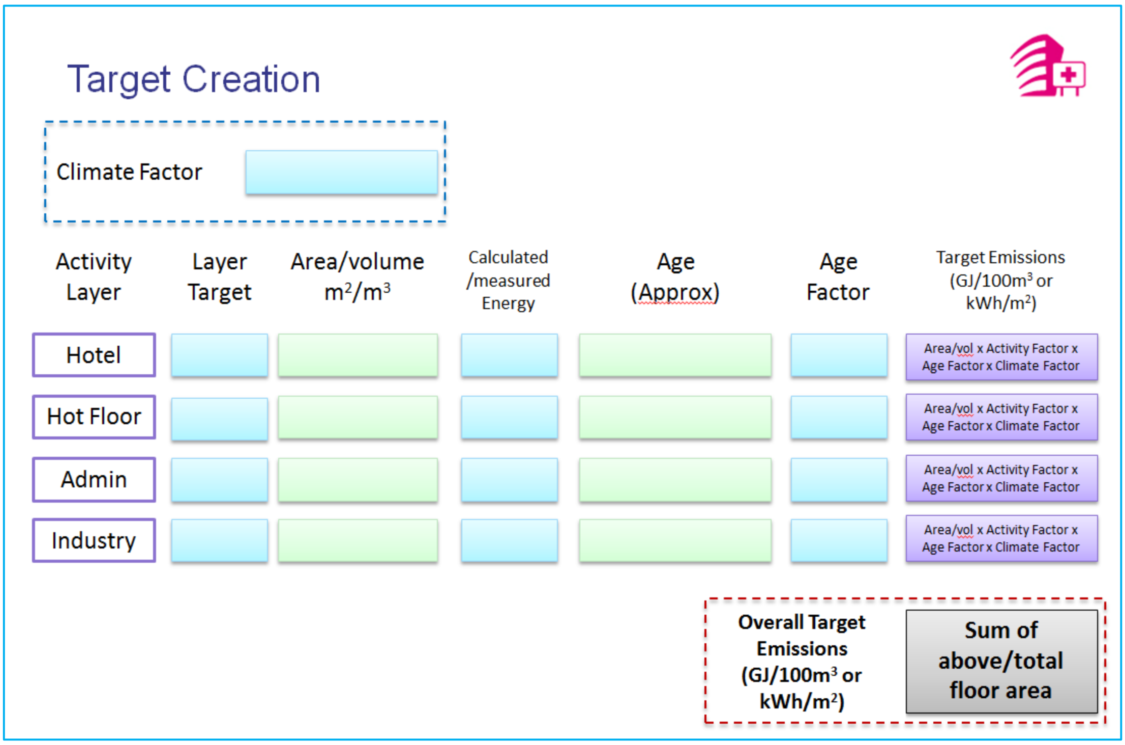


Figure 11 Potential presentation matrix for energy comparison

### 7.6 Short Example showing use of factors

- Existing healthcare facility
  - 1,000m3 of office
  - 250m3 of hotel
  - Located in Poland
- Layer targets may be (unadjusted activity factors):
  - Office – 25 GJ/100m3
  - Hotel – 40 GJ/100m3
- Layer targets then adjusted by climate factor (Example Poland factor = 1.1):
  - Office – 27.5 GJ/100m3
  - Hotel – 44 GJ/100m3
- Layer targets then adjusted by building age (Example 1980s build = 1.4)
  - Office – 38.5 GJ/100m3
  - Hotel – 61.6 GJ/100m3
- Based on the building volumes this will equate to an overall target of:
  - 43.1 GJ/100m3
- Existing building should then be compared to this target – remedial measures may be required if lower

# 8. Creating a financial model for comparison

A financial appraisal is essential when comparing a number of options either for a new facility, for a refurbished facility of for the upgrading of a system. There are a number of options available including a whole life costing analysis via a discounted cash flow model or a less complex “simple payback” analysis. The decision to employ either one of these options must rest with the hospital client and will depend on the size of the project, the type of project and the stage at which the project is being evaluated. This next section deals with the procedure to provide an economic appraisal of different solutions to a given problem via a discounted cash flow arrangement using a net present value technique. The broad requirements to develop the analysis are illustrated in Figure 12 below (Ref4).

| | |
|---|---|
| **STEP 1** | Define the problem |
| **STEP 2** | Develop the models |
| **STEP 3** | Perform calculations |
| **STEP 4** | Sensitivity analysis |
| **STEP 5** | Interpret the results |

Figure 12 The stages to a Whole Life Cost analysis

Within the broad framework for project decision making, Whole Life Costing is a major assessment criteria however there are others. These have to be taken into account and often there will be a compromise. Figure 13 shows a typical assessment required for project decision making that fulfills the requirements of Streamer.

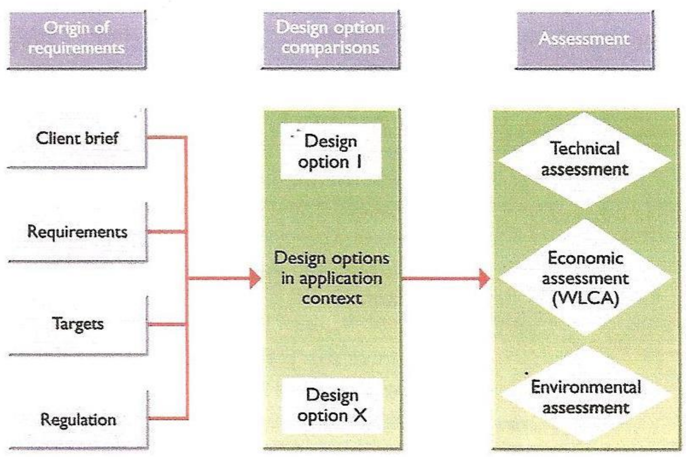


Figure 13 Project decision making assessments

There may be an additional assessment in a healthcare environment and that would be the clinical assessment of the proposed alternatives. In short there will be a number of stakeholders involved in the decision process and they will want their particular interests' considered. However, the case for higher capital investment in return for lower running costs and improved worker productivity is a Streamer requirement and therefore fit extremely well with a WLC approach.

To engage in a WLC analysis a significant amount of data is required. This is the cost data of individual activities and components that make up the project options; and data about the timing of future events. The timing of events is concerned primarily with the life expectancy of the building components.

A detailed example of the process appears in Reference 5, which was used to develop this section. The general approach is best considered in an example which would be typical of a Streamer project.

## 8.1 WLC project analysis example

The facilities team of a large hospital has benchmarked the energy use and maintenance costs of a 2,000m2 out-patient department (OPD) with similar facilities in other hospitals. Approval has been given by the estates director to upgrade the facility to provide cost savings over a period of 17 years, by which time the OPD service may be de-centralised and moved into more local community facilities.

The estates director is developing a base case and 3 alternative cases.

**Base Case:** *Do nothing and retain the existing equipment and live with the energy usage, maintenance and expected service life, replacing the equipment as and when it reaches the end of its life. The existing* *boilers use 250,000kWh of gas each year and the air handling unit uses 100,000kWh of electricity. The replacement equipment will have the same performance as Option 1.*

**Option 1:** *Replace the boilers and the air handling unit with items of plant at the lower end of the available price range, which are 10% more energy efficient than the existing plant and will require annual maintenance.*

**Option 2**: *Replace the boilers and the air handling unit with items of plant at the higher end of the available price range, which are 25% more energy efficient than the existing plant and require maintenance only every 2 years.*

**Option 3:** *Replace the existing boilers with a combined system comprising a smaller boiler and a double façade on the south facing side of the building to pre-heat internal air in the winter. Maintain the existing air handling unit but replace it as per the base case. The combination of a small boiler and double façade reduces the gas required for heating by 60%.*

In order to now consider a WLC analysis to each option the following information is required.

**Discount rate:** A consistent rate for all options and differs between the public and private sector. For this example a discount rate of 5% is considered appropriate.

**Selecting the study period**: This period must be the same for each option considered. For this example a period of 17 years is used. This is a key time period after which the facility may be changed.

**Building the data:** We need to understand the timing of events and the cost implications of those events. There are two types of events to be considered 1) lump sum/one off activity and 2) recurring activity.

Examples of one off activity in this example are:

1. Initial installation
2. End-of-life replacement
3. Major repair or maintenance work part-way through the study period
4. Decommissioning costs
5. Residual value at the end of the study period

Examples of recurring activity in this example are:

1. Annual maintenance/cleaning contract costs

2. Energy costs

| Cost item | Cost | Price rise (above inflation) |
|---|---|---|
| **Gas** | 5.63 cents/kWh | 10% increase every 5 years |
| **Electricity** | 16.9 cents/kWh | 7% increase every 5 years |

3. Staff costs

4. Rent or lease payments

**Timelines for base case and 3 options**

The lump sum and recurring costs are plotted on an events timeline as shown in Figure 14.

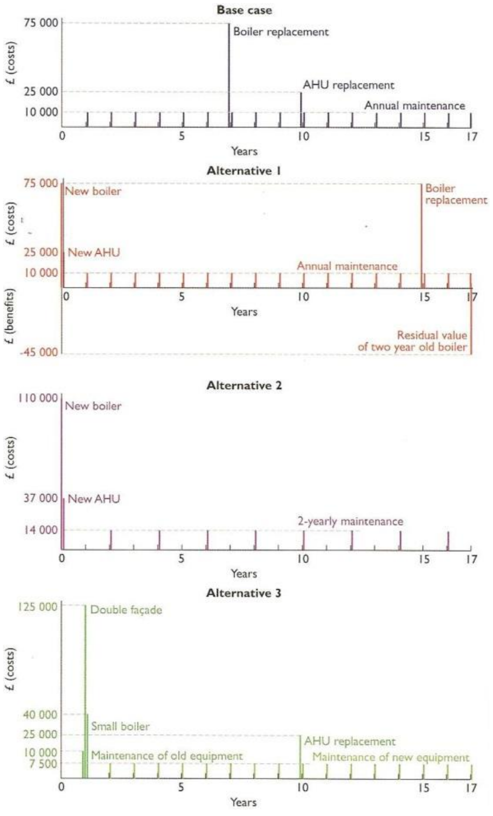


Figure 14 Events timeline for all options

**Net Present Value models:** A mathematical model is constructed for the lump sum and recurring cost elements in each option with the latter reflecting changing costs over the agreed study period.

**Conclusion to the WLC analysis:** From the data input and the NPV model that was constructed the WLC costs are shown below. The lowest WLC cost represents the most economically advantageous figure and in this analysis Option 2 is the best value option from a WLC perspective.

| Base case | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| €566,435 | €602,886 | €538,440 | €575,632 |

Using a whole-life costing approach as the financial basis for an option appraisal exercise is an intelligent way of considering the long term financial implications of important project decisions. It forces us to think about the long term implications of our decisions and that is a desirable approach to take.

# 9. Quality of the Environment and Operational efficiency

The third KPI that is considered appropriate for the Streamer project is that of quality of the environment and the subsequent operational efficiency. It is important that in taking a balanced approach to the comparison of options of energy efficiency we recognise the full value that a well-designed facility can offer the operator of healthcare facilities. This section has been influenced by the NHS AEDET Evolution Toolkit (Ref6)

a) The cost of recruiting and retaining staff
b) The benefits of efficiently designed spaces to ensure operational effectiveness
c) The ability to change the use of spaces and to still maintain operational efficiency
d) The confidence that a quality environment gives to the family and friends of patients
e) The increase in staff morale due to the design considerations' made on their behalf
f) The effect the environment has on the patient and their ability to recover quicker.

The difficulty in defining "quality" in the built environment is well known and starts from the premise that quality will differ depending who is adjudicating. Also, operational efficiency particularly in the acute sector of healthcare comes with compromise i.e. there is no hard and fast rule to achieve success. Where perhaps the industry has failed in the past is the poor record in securing "post occupancy evaluations" of completed projects – this must be an essential part of the whole life cycle "story" of any healthcare facility – as designers did we achieve what we set out to achieve in terms of quality of design and operational efficiency and what evidence have we for the answer to that question?

In order to bring together quality and efficiency we should consider the elements that should be considered when planning to create the “right” environment for staff, patients and carers. We can use a number of terms for this including “well-being” environment, “salutogenic” environment, ”well-ness” environment and “ therapeutic” environment. For the purposes of this report we are using the last term.

## 9.1 Elements of a therapeutic environment for the Streamer project

Some examples of the component parts that need to be considered to develop a therapeutic approach in an acute healthcare campus/district and associated facilities are shown below.

a) *Sufficient car parking and public transport connections for the benefit of staff arriving or leaving their place of work, when outpatients are arriving for tests when family and friends are contemplating an in-patient visit. The greater the degree of difficulty in the “whole journey” experience will increase the levels of stress experienced by the individual.*

b) *Clear way-finding whether from car park or public transport terminal to hospital campus/district, travel in-between buildings or from department to department within a building can have an impact on operational efficiency. Eliminating the inconvenience associated with late arrival for appointments, increased confusion and the associated stress levels and importantly the elimination of clinical staff having to spend valuable time explaining directions are important areas to consider.*

c) *Privacy & dignity is a significant component of the modern day hospital environment. We have a new patient generation who will have grown up having individual spaces in their dwellings from a very early age. We also have a more multi-ethnic mix which requires sensitivity and more clinical activity can and will in the future be carried out around the bedside and personal ITC activity will demand privacy. The obvious solution to satisfy this requirement is single is-patient accommodation.*

d) *Security is becoming more into focus with the need to protect patients, staff and visitors from unwanted disturbances. It is important that members of staff feel safe not only in their place of work but also on their journey from the car park or bus terminal to their work-place. The same requirement is required for visitors and patients.*

e) *Appropriate acoustics is a key requirement of the modern hospital and is aligned to privacy and dignity with cleanable surfaces to reduce infection a major cause of noise reflection. However, the break-out of noise from one space into another is unacceptable. Traffic noise particularly in an inner city environment is to be considered at the earliest planning stage. There is also a need to ensure that unwanted disturbance such as that from staff bases and monitoring devices is kept to a minimum especially at night.*

f) *Natural daylight has long been considered one of the most important requirements of an effective therapeutic environment. There is now a greater level of understanding of the effects of the body's circadian rhythm which included the "switching" of the body's sleep/wake cycles and hormone release. There should be no hospital space designed that does not include natural daylight. A further benefit is that of reducing the need for artificial lighting by maximizing the natural light which reduces electrical consumption.*

g) *Interesting/relaxing views are considered extremely important particularly in the acute healthcare environment and there is evidence to support this. It is important for patients and staff to be aware of their visual connection to their external environment. To share the everyday normality of life or perhaps reducing the stress levels of work activities and treatment by well-designed or visual exposure naturally occurring vista.*

h) *Access from and to different departments and walking distances both between departments and within departments has been a major consideration in the design of acute healthcare facilities. There is no doubt that there are compromises to be made relating to the operational walking distances and the amount of glazed elevation, natural daylight and natural ventilation that can be accommodated.*

i) *Reducing the risks of hospital acquired infection is essential in the acute environment as the risks of infection are high and the outcomes can be fatal. Much is known about the need to put in place a design strategy that considers the major routes of transmission of infection and this should be put into place with the support of the campus/district/department infection control officer.*

j) *Thermal comfort is a key component in the creation of a therapeutic environment. Different systems can be introduced to ensure the patients and staff has the right level of heating and ventilation with cold drafts or warm stuffiness being avoided. There is no doubt that there is a broad range of comfort requirements between a working staff member and a patient in bed and this is a major challenge for designers.*

k) *Environmental control of the internal spaces will always be difficult in the acute hospital given the broad range of comfort conditions required by the occupants. There will also be a different range of complexity due to thermal conditions required being driven by the specific hospital layer being designed (diagnostic/treatment and ward etc). One major consideration in the ward and admin areas is the use of manually operable windows hence allowing the occupants control of their own environment through natural ventilation. This has the multiple benefit of reducing the reliance of sophisticated ventilation controls, reducing energy (particularly in spring and autumn) and also gives control back to the occupants.*

l) *Artificial lighting is a major user of energy in the acute healthcare district/campus. The use of LED systems is now common-place in hospitals as is the ability to reduce artificial lighting levels at specific periods through dimming, timing and occupancy control systems. Importantly is the need to design in large areas of glazing to ensure that the space experiences the maximum amount of natural daylight which renders unnecessary, the use of artificial lighting for large period of the day.*

m) *Art in the acute hospital environment can be extremely relaxing, can become a focus of interest and also help to reduce the institutional "feel" of the facility. It is important consider the use of art in detail engaging specialists. The use of local artists, the integration of local schools and art colleges in the sourcing of the art and the ability to change the position of pictures and photographs regularly to ensure that they do not become "wall-paper" in the eyes of staff are all important considerations.*

n) *Entertainment systems have been in place in acute hospital environments' for many years. Originally driven by public radio and hospital radio stations. Now the focus must be on the use of the internet and of social networking sites to enable the developing patient population that embraces the new media revolution to easily engage in these everyday facilities.*

One proven method to assess some of the component parts of the "therapeutic environment" is the BUS Methodology which has been developed over many years and is commercially available.

# 10. Developing a practical and integrated methodology based on the Streamer KPI's

Having now developed the 3 KPI's necessary for a balanced approach within the Streamer project we can bring them together to consider how to achieve the optimum solution when considering the project options available. It is envisaged that the initial thinking for the project team will be based on a clinical brief and a number of options for the placing of the facility on the site. There will need to be a significant amount of site knowledge that highlights the "on-costs" of the options to be considered as well as the building costs. These "on-costs" could range from contaminated land to insufficient utilities available at the site and will need to be considered within the cost analysis.

An overarching understanding of the key energy related issues raised in section 3 which includes the general design, construction, maintenance and operational considerations will need to be embedded in the process. These can be amended for different national design and construction standards and for different climates, however, the principals of the requirements should not be lost.

At the centre of the comparison will be an energy model which takes the geographic, dimensional, positional, construction and operational elements of each option and converts the information into a dynamic energy model. The energy usage will then be calculated and compared with the agreed range of energy target as set out in section 5. Depending on the results achieved there may need to be construction modifications and operational refinements made to the thermal model to bring a particular design option into target compliance. It should be noted that the energy target will need to be flexible to address the different national standards and climate but should not be flexible to the point where the fundamental principles of Streamer are not met i.e. a 50% reduction in energy use. An example of the energy related questions upon which the options are scored and upon which the energy models are based are shown in Figure 15. This would take the form of a software driven questionnaire which would be scored by the project stakeholders. There may be a requirement for weighting some of the answers depending on the type of project to be undertaken.

| Overriding energy saving parameters | Base case | OPTION 1 | OPTION 2 | OPTION 3 |
|---|---|---|---|---|
| Primary energy source and capacity | | | | |
| Operational brief in place | | | | |
| System spatial capacity & flexibility | | | | |
| Renewable energy opportunities | | | | |
| System resilience against climate change | | | | |
| Building envelope efficiency | | | | |
| Natural ventilation strategy | | | | |
| Plant room capacity for maintenance | | | | |
| System distribution capacity | | | | |
| System reliability against failure | | | | |
| Effective zoning of plant | | | | |
| Efficient plant and distribution systems sizing | | | | |
| Control strategies in place | | | | |
| BMS design | | | | |
| Commissioning planning | | | | |
| Sub Total | | | | |

Figure 15 Overriding energy saving parameter to be scored against each option

Once all of the design options have reached a satisfactory energy target compliance they must then have their capital and revenue costs calculated from local benchmarked data or by other acceptable means and a whole life costing process applied as explained in section 6. The highest to lowest whole-life cost results can then be used as part of the decision making process with the lowest WLC figure being the preferred result. Figure 16 shows a potential output table of information required for inclusion in the option appraisal.

| WLC Analysis | Base case | OPTION 1 | OPTION 2 | OPTION 3 |
|---|---|---|---|---|
| Lump sum activity (one off) | €82,377 | €139,730 | €176,400 | €206,989 |
| Recurring activity (on-going for defined period) | €484,058 | €463,156 | €362,040 | €368,643 |
| WLC | €566,435 | €602,886 | €538,440 | €575,632 |
| Discount rate (5%) | | | | |
| Defined period (17 years) | | | | |
| Preferred option | | | First | |

Figure 16 Whole Life Cycle costing analysis

The final part of the option appraisal process through this KPI driven comparator is the quality of space and operational efficiency as set out in section 9. This will be a subjective review of the options presented via a software based questionnaire. It is envisaged that the questions presented, although not exhaustive will be a reasonable starting point for a mixed group of stakeholders to present their view on the potential for the scheme to be of the highest quality and most operationally effective. Depending on the national and local standards, the climate parameters and the type of facility to be provided, there may be a case for weighting some of the answers. This would be agreed with the project director/leader prior to the start of the process and written into the software questionnaire. Clearly the same weighting would apply to all options so that the final selection will have been made on an equal basis. A possible presentation format is illustrated in Figure 17 below with the necessary KPI's highlighted.

| Elements of the therapeutic environment | Base case | OPTION 1 | OPTION 2 | OPTION 3 |
|---|---|---|---|---|
| Car parking and transport connections | | | | |
| Clear way-finding (internal & external) | | | | |
| Privacy & dignity | | | | |
| Security | | | | |
| Acoustics | | | | |

| | | | | |
|---|---|---|---|---|
| Natural daylight | | | | |
| External views | | | | |
| Access and walking distances | | | | |
| HAI strategy | | | | |
| Thermal comfort | | | | |
| Environmental control | | | | |
| Artificial lighting | | | | |
| Art | | | | |
| Entertainment systems & ITC | | | | |
| Sub Total | | | | |

Figure 17 Practical elements of a Therapeutic environment

# 11. Conclusion

The Streamer project is primarily about the energy reduction in the acute healthcare campus/district site. It is being developed to allow operators of these facilities to be able to compare and contrast options when they are considering a development. This development can be anything between a large new build to a small refurbishment. In order to compare and contrast options there needs to be a basic decision making process to move the project on to the next phase of detail design. The development of a set of KPI's is important to enable a measure of performance to be illustrated which can then form the consistency that is necessary for fair option selection.

It would be easy to develop a KPI that focussed only on an energy target and compare the options against the quoted target. However, we have applied a more balanced approach to our process, not least of all because the selection of optimum solutions now more than ever depends on extremely complex multi-faceted/multi-discipline decision making processes. The simple intervention that makes significant change that is satisfactory to all stakeholders no longer exists.

The KPI's selected for Streamer involve the efficient use of energy through an energy targeted approach, the capital and operational costs through a whole life cycle cost and the development of the highest quality of environment and operational effectiveness through the development of a therapeutic environment. By considering these 3 KPI's we believe that significant lower energy and higher quality environments will be achieved within the acute healthcare district/campus site.

Summary Table 1. Source of indicators (References)

| Streamer KPI's | Source of indicators |
|---|---|
| 1. Energy Performance and Efficiency | 1.NHS England carbon emissions: carbon foot-printing report – September 2008. www.sdu.nhs.uk |

| | |
|---|---|
| | 2. BREEAM for non-domestic buildings (currently 2011 version only applies to new build)*<br>3. Health Technical Memorandum 07.02 UK NHS<br>6. Making Energy Work in Healthcare.<br>Environment and sustainability, Health Technical Memorandum, 07-07: Sustainable health and social care buildings |
| 2. Financial base for comparison WLC | 4.BSRIA Guide BG 5/2008 – Whole-Life Cycle Costing Analysis |
| 3. Quality of the Environment & Operational Efficiency | 5.AEDET Evolution – NHS Evaluation Toolkit. |

* BREEAM 2011 incorporates the majority of environmental performance measures proposed for evaluation in CEN/ATC 350 standards, together with a significant number of the social performance and some economic measures. Obvious examples include using Life Cycle Assessment (LCA) based data through the application of the Green Guide; Energy consumption in use through the application of SBEM, the UK's PD compliant National Calculation Methodology, and water consumption through the BREEAM water calculator tools. Outputs give KPIs on Energy and Water in compliance with the draft standards and BRE Global will be introducing others following the final release of the CEN/TC 350 Standards.

Summary Table 2. Alignment of indicators to Streamer KPI compliance

| Elements of compliance | Sources | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **KPI 1 – Energy performance & efficiency** | | | | | | |
| Primary energy source and capacity | | X | X | | | X |
| Operational brief | | X | X | | X | X |
| System spatial capacity, flexibility and adaptability | | | X | | X | X |
| Renewable energy | | X | X | | | X |
| Climate change | | X | X | | | X |
| Building envelope | | X | X | | | X |
| Natural ventilation | | X | X | | | X |
| Maintenance access | | X | | | X | X |
| System capacity | | | X | | | |
| System reliability | | | X | | X | |
| System zoning | | X | X | | | X |
| Efficient plant and systems | | X | X | | X | |
| Effective control | | X | X | | X | |
| BMS design | | X | X | | | |

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Commissioning planning | | X | X | | | |
| Construction & procurement process | | X | X | | X | X |
| Effective maintenance | | X | | | X | X |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **KPI 2 – Financial analysis based on whole life costing** | | | | | | |
| Whole life costing | | X | X | X | | X |
| Whole life costing - methodology | | X | | X | | X |
| | | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **KPI 3 – Quality of environment & operational efficiency** | | | | | | |
| Car parking and transport connections | | X | | | | X |
| Way-finding | | X | | | X | X |
| Patient privacy and dignity | | | | | X | |
| Security | | X | | | X | |
| Acoustics | | X | X | | | X |
| Daylight | | X | X | | X | |
| Views | | X | X | | X | X |
| Accessibility & walking distances | | X | | | X | X |
| HAI strategy | | | X | | | |
| Thermal comfort | | X | X | | X | X |
| Environmental control | | X | X | | X | X |
| Artificial lighting | | X | X | | X | X |
| Art | | X | | | | |
| Entertainment & ITC | | | | | | |