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Gaming Energy Refurbishment †

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Abstract: This paper reviews the sustainability strategy of a major hospital campus, and the progression from large and compelling improvements through to the need for careful management of further incremental changes. The use of gaming strategy to optimize the refurbishment of two specific hospital departments for energy efficiency is examined. Standard energy assessment tools are repurposed to work in situations where there is limited information.

Keywords: sustainable buildings; refurbishment; energy saving; modelling and simulation

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1. Introduction

Public bodies in the UK such hospital trusts are under increasing budgetary and legal pressures to reduce the cost and carbon profile of their operations. The uses of these buildings may be very different from those originally envisaged.

1.1. The Example Health Campus

In 2008 The Rotherham Foundation Trust (TRFT) [1] participated in Phase 2 of the National Health Service (NHS) [2] Carbon Management Programme in collaboration with the Carbon Trust. Rotherham Hospital was built in three phases commencing in 1978 and a large amount of the infrastructure is still in use, therefore a major retrofit programme would produce substantial savings in energy and carbon. Much of the original lighting and heating hardware is still utilised and heating control is very basic.

1.2. Energy Strategy

TRFT initially focused on four major initiatives which were planned to impact the energy profile across the entire district. Despite all these limitations and constraints, a steady reduction in carbon emissions attributable to building energy use has been seen at Rotherham Hospital. With finances becoming increasingly tight, projects have to be identified and acted upon in a much more measured manner—hence TRFT participation in Project STREAMER [3].

1.3. Research Project

The EU Streamer is an EU FP7 [4] collaborative research project with technology partners KIT [5], AEC3 [6], Demo (NL) [7], TNO [8] and CSTB [9], and the four case study hospitals. The team adopted the EU STREAMER conception of a higher level model where only whole zones and systems would be considered. The TRFT model was developed in such a way as to respect the limited information available but still produce results that were potentially relevant to the operational team. Modelling at the zonal (departmental) level meant that detailed room layouts and equipment lists would not be needed. The operational cycles (daily, weekly, yearly) would be applied across all the spaces in that department. Similarly, modelling at the system (fabric, structure or MEP) level meant that detailed service runs, fabric details or in most cases emitters would not be needed. This allowed high level cost information to be applied.

2. Past Energy Performance

Figure 1 shows current performance since the inception of the Carbon Management Plan (CMP) baseline year 2007/08 up to and including the current year. The initial target from the Carbon Management Plan in 2008/09 was a 30% reduction over the next 5 years. In 2015/16 this target was reached and this year has been matched, even though the CHP has endured long periods of inactivity.

3. Discussion

The UK Government Department for Health 'ERIC' [4] reporting confirms that there is a huge range of performance by whole districts, which must also suggest that there is a potentially wide range of performance of individual zones arising from differences in activity, fabric and MEP systems, construction and systems. This suggests that, until there are benchmarks at least for activities based on live monitoring, it will be difficult to reconcile the wide variations in the figures found in the Tables 1 and 2 below.

Table 1. Energy metric published by TRFT, predicted for two departments by SBEM and as monitored.

W/m^2	Published	SBEM	Metered
Electricity Power Consumption 2007	17.5	34.7	
Gas Power Consumption 2007	53.3	24.9	
Electricity Power Consumption 2015	2.4		
Gas Power Consumption 2015	66.1		
Power Consumption		59.5	
Heating power demand (gas)		17.9	
Auxiliary power demand (electricity)		3.8	
Lighting power demand (electricity)		19.0	5.9
Hot water power demand (gas)		6.9	
Equipment power demand (electricity)		11.8	3.0

Table 2. Change in power demand density for an example upgrade proposal made by RDaSH [5] maintenance team.

RDaSH Proposal Package	Delta W/m^2
Heating power demand (gas)	−25.0
Lighting power demand (electricity)	+2.3

4. Methods

4.1. Information Capture and Creation of the Baseline Campus

As each information resource was identified, it was mapped to become a coherent 'sub-model'. So as to give TRFT a physical representation and geo-spatial location, a simple block model of the campus was created and then exported to IFC. Most of the other information resources were mapped to create IFC sub models by representing the incoming data as a spreadsheet format, such as CSV or 'Spreadsheet XML 2003'. Some resources, such as the electrical sub-circuit meter readings had a less disciplined format and special transformations were created. Lastly, the written description was marked up using AEC3 UK Require1 [6] to identify the scope and descriptive definitions. A single baseline model was created, representing the current hospital campus, by merging together the sub models derived from the various information resources available. In response to users' proposals as part of the 'gaming' exercise, the baseline model was filleted to leave in only the selected options. Each input model was transformed into the input format of the chosen energy simulation package, UK NCM SBEM. The simulation process generated energy results (in a loose CSV format) which were transformed and added back into the input model.

4.2. Gaming

A key goal was to investigate the participant's perceptions of the solution space and their tacit knowledge in an interactive way. It was decided to exploit operational 'gaming'. Gaming can be summarized as the setting up of a competitive scenario in which the participants have limited information and/or options, reflecting a simplification and bounding of a real world situation [7]. The limited options were the upgrade options from the consultant's report, the competitive element was provided by having several separate teams, with the results only being shared once all choices had been made. Each participant was obliged to vocalise their tacit knowledge and understanding of the sparse information in order to persuade their fellow team members.

5. Conclusions

The majority of energy analysis tools are predicated on detailed descriptions of building spaces and components. Linking in information from BIM authoring tools is sometimes possible. In some cases, such as UK NCM SBEM [8], it is possible to use the tools with a higher level description, focusing on zones and systems. It may be possible to develop a hybrid approach and tools where a design in various stages of development, at various stages in its life cycle, is analyzed much more frequently.

Once a team had chosen their options, the gaming process took around five minutes to prepare the appropriate model, run the simulation and consolidate the results. It could be useful to re-visit the process to eliminate or accelerate steps in the simulation process.

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Conflicts of Interest: 'The authors declare no conflicts of interest.

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