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Communication

Evaluating the scope for energy-efficiency improvements in the public sector: Benchmarking NHSScotland's smaller health buildings

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Abstract

The National Health Service in Scotland (NHSScotland) has, in recent years, done much to reduce energy consumption in its major healthcare buildings (hospitals). On average, a reduction of 2% per year has been achieved since 2000, based on hospital buildings. However, there had been little or no attention paid to smaller premises such as health centres, clinics, dentists, etc. Such smaller healthcare buildings in Scotland constitute 29% of the total treated floor area of all NHSScotland buildings and, therefore, may contribute a similar percentage of carbon and other emissions to the environment. By concentrating on a sample of local health centres in Scotland, this paper outlines the creation of an energy benchmark target, which is part of a wider research project to investigate the environmental impacts of small healthcare buildings in Scotland and the scope for improvements. It was found that energy consumption varied widely between different centres but this variation could not be linked to building style, floor area or volume. Overall, it was found that a benchmark of 0.2 GJ/m^3 would be challenging, but realistic.

Keywords: Energy; Benchmark; Healthcare buildings

1. Introduction

Our environment is being severely damaged by combined social and economic development: the planet's ecosphere is dynamic but the impacts of human activities are becoming greater than nature's ability to cope with them. A key problem is the emission of global warming pollutants or greenhouse gases (GHG).

However, while the damage to human and environmental health from carbon release alone is potentially very large, there are other emissions that should also be considered. Pollutants such as nitrogen oxides (NO_x), sulphur oxides (SO_x) and particulate matter (PM_{10} and $PM_{2.5}$) are also released during power generation (Murray et al., 2004). These pollutants have a direct effect on human health, and it could be argued that an organisation such as NHSScotland, whose sole purpose is to make and keep people healthy, should be concerned about its contribution to the accumulation of such substances in the atmosphere as well as the wider impacts of carbon release.

In Britain, 32% of the total electricity requirement is derived from coal-fired power stations (DTI, 2003) and the Government is committed to a 12.5% reduction of annual GHG emissions by 2008–2012, based on 1990 levels, an a 20% reduction in carbon dioxide (CO_2) emissions by 2010, even though it is currently not on target to meeting this (Black, 2005). It follows that national institutions such as the NHS should strive to contribute to achieving these targets.

The latest British energy baseline for major health buildings (heating and base load) was 2.2 GJ/m^2 per year, while the recommended good practice benchmark for these large health buildings was 1.5 GJ/m^2 (BRE, 1996). In 2003, the Health Service in England saw an increase in energy consumption on the previous year of 0.56 GJ/m^2 from 1.69 to 2.25 GJ/m^2; this 33% rise was on a decrease of 2% of the total treated floor area for England for that year (DOH, 2004). Data from Welsh Health Estates show Wales to

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have a consumption baseline of 2.24 GJ/m^2 for 2003 (WHE, 2004), for medium to large buildings only.

In comparison, the NHS in Scotland appears to be faring slightly better. In 2003, NHSScotland's mean consumption for major hospitals was 1.68 GJ/m^2 (PEFEX, 2004), which highlights the efforts NHSScotland have made in reducing its contributions to the environmental impacts of its buildings. The main drivers for NHSScotland in reducing energy consumption are cost and reducing its contribution to climate change (Le Breton, 2005), and it aims to reduce consumption by 2% per year between 2000 and 2010 (PEFEX, 2006). NHSScotland has done much in recent years to reduce energy consumption in its larger acute healthcare buildings, achieving on average the target reduction of 2% per year since 2000, even though potential cost savings are negated by increasing energy prices.

However, these savings reflect only major hospital buildings. Little or no attention has been paid to smaller premises such as health centres, clinics, and dentists, etc., despite the fact that these ~1000 smaller buildings account for 29% of the overall floor area of NHSScotland premises, and thus present a considerable potential for further savings. Similarly, no relevant information on these types of smaller healthcare buildings has been found in the literature.

Against this background, this study analyses the energy consumption in smaller health service buildings in Scotland in order to establish the current status quo of energy consumption in such buildings and to create a realistic energy benchmark that can help in setting achievable targets to minimise energy consumption. For the latter (meta-) aim, this study draws on the work by Filippin (1999) and Chung et al. (2006), who demonstrated the usefulness of benchmarks in this context, while acknowledging the problems that lack of data in some areas can cause (Warnken et al., 2003). The principal function of the smaller health care buildings is primary diagnosis and health care on an outpatient basis, and is therefore comparable to that of small office complexes. This paper describes the initial stage of creating an energy benchmark target for these buildings in Scotland, so-called 'C5' buildings.

2. Energy benchmark for smaller healthcare buildings

2.1. Data sources and baseline data

Initial search for data on NHSScotland smaller buildings met with some difficulties. For example, the definition of "smaller buildings" is not consistent throughout NHSScotland. In some cases it was not clear which buildings NHSScotland Health Boards were responsible for, and energy data for many C5 buildings were not readily available. Anecdotal evidence further supported the idea that there was a need for this investigation as it confirmed that there was little evidence of a holistic understanding of the environmental performance of smaller buildings within NHSScotland. The information collected as part of this research has shown that there are approximately 1600 "smaller buildings" in Scotland, and 1008 of these are NHSScotland C5 premises. This being the case, health centres and clinics represent 55% of the total number of NHS buildings in Scotland and account for 29% of total floor area.

The data for the sample audit were gathered from a random sample of 180 C5 buildings from every NHSScotland Board for the year ending 31 March 2001 (PEFEX, 2004). The locations of the buildings in the sample were spread over all of Scotland geographically, and ranged in size from 82 to 4461 m^2, though most were between 200 and 2000 m^2. The information included treated floor areas (TFA) as well as heated volumes (HV); it also included types of heating system and fuel used, and the total costs of energy consumption for each building. The sample audit showed a range in building size for treated floor area between 82 and 4461 m^2 and heated volume of 205–10,812 m^3. The average TFA for the sample is 1017 m^2 and average HV is 2532 m^3.

The sample audit also showed a total energy for heating in 2001 for 181,075 m^2 floor area to be 43.2 GWh (Table 1). Using a conversion factor of 0.23 kgCO_2/kWh, which includes upstream emissions (DETR, 1999), this gives 54.8 kgCO_2/m^2 per year. Similarly, the annual CO_2 release for electricity consumption was 31 kg/m^2, resulting in a total CO_2 emission of 86 kg/m^2 per year.

The data did not include, for example, detailed information on the types of services offered on each of the premises. However, these buildings were principally outpatient health centres, providing GP surgery accommodation and other related health care services. As such, they could be expected to have similar requirements in terms of hours of operation and water use. These particular items of information are not generally available. However, from the data available from the pilot study buildings it was possible to extrapolate that these buildings have hours of operation that are very similar to those of small office blocks: average opening hours are 47.5 per week. The

Table 1
NHSScotland carbon dioxide emissions from electricity and heating

Energy use	Energy consumption (kWh)	Treated floor area (m^2)	kWh/m^2	CO_2 conversion factor (kgCO_2/kWh)	CO_2 emission (kgCO_2/m^2)
Heating	43,199,075	181,075	239	0.23	54.8
Electricity	12,896,478	181,075	71	0.44	31.3
				Total kg CO_2/m^2	86
				Total tonnes CO_2	15,572

smallest opening period was that of the smallest building, operating a part-time service in a remote area, at 20 h per week. The longest opening hours were offered in a large built-up area at 56 h per week including evening and Saturday surgeries.

The energy data from the sample audit show no correlation between electricity and heating by volume (Fig. 1). This is not surprising, because the ratio between heating fuel (mainly gas) and electricity use depends on the uses for electricity. Some premises, for example, were electrically heated (these are not included in Fig. 1), some could rely heavily on fan heaters and other electric ad-hoc heating elements during cold weather, and others could use electric point heaters for hot water. For those premises using gas or oil for heating, the ratio between heating fuel and electricity ranged from 0.55 to 31.8, with a mean of 4.7 (standard deviation 3.0).

There is good correlation when comparing heating energy consumption by area and volume (Fig. 2), which are related by the average ceiling height in the building, which for most buildings is shown to be between 2.2 and 3 m. However, heating energy consumption correlated poorly against other parameters, such as age or type of building and physical location.

Extrapolation of the data estimates the total TFA of NHSScotland C5 buildings as $1.025 \times 10^6\,m^2$, with a total estimated energy consumption of 1.143×10^6 GJ/a. This gives an average annual energy consumption of 1.11 GJ/m^2 with a surprisingly wide range of between 0.275 and 3.83 GJ/m^2. Estimating by total heated volume, which is a major factor in energy consumption (Fairbairn, 1992), gives an average consumption of 0.45 GJ/m^3 (Table 2) with a range of 0.11–1.53 GJ/m^3 per year.

2.2. Existing comparators

Typical guidelines and good practice data for similar type buildings, based on small office specifications

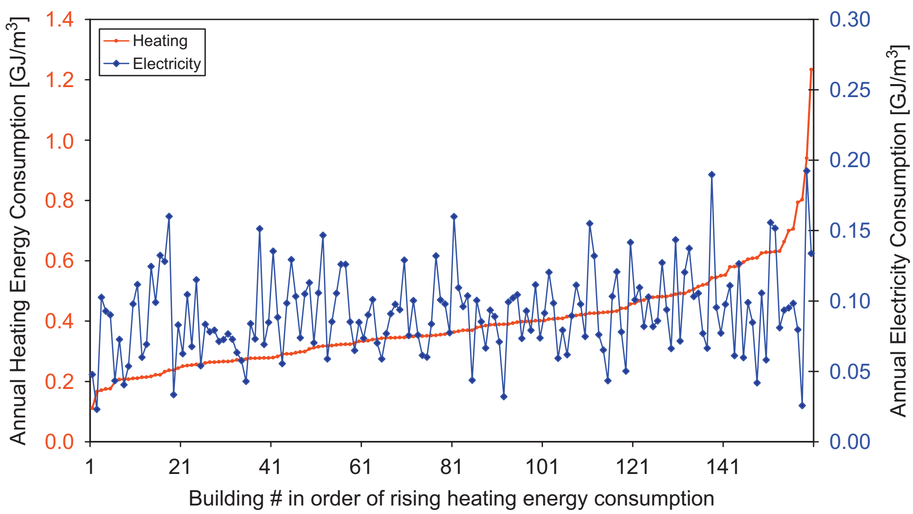

Fig. 1. Range of energy consumption, heating and electricity, by volume (PEFEX, 2003).

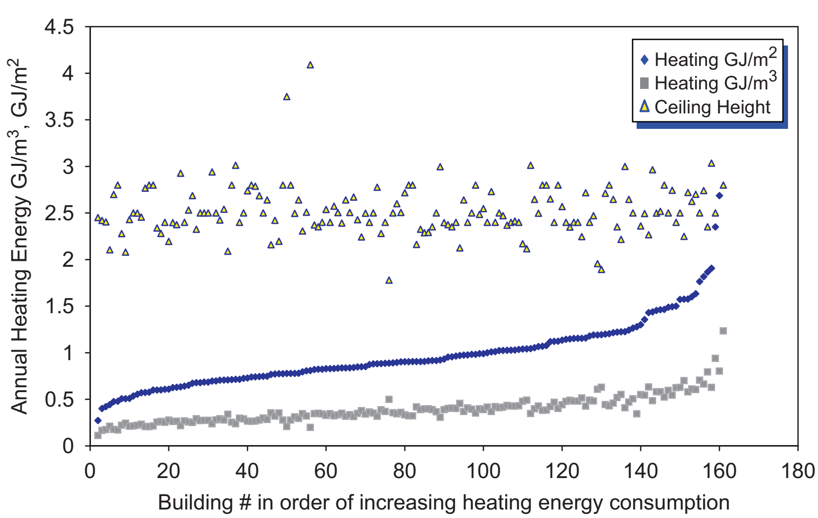

Fig. 2. Correlation of heating energy consumption by area and volume, including ceiling heights (PEFEX, 2003).

Table 2
Comparison between typical/good practice guidelines and NHSScotland consumption

	Energy consumption					
	Heat (kWh/m^2)	Electric (kWh/m^2)	Aggregate by area		Aggregate by volume	
			(kWh/m^2)	(GJ/m^2)	(kWh/m^3)	(GJ/m^3)
NHSScotland average	239	71	310	1.11	124	0.45
BRE typical baseline (small office)	151	54	205	0.74	82	0.30
BRE good practice (small office)	79	33	112	0.40	44.8	0.16

BRE (1999) and PEFEX (2003).

(Table 2), are estimated as 0.74 and 0.40 GJ/m^2, respectively, by the Building Research Establishment (BRE, 1999). NHSScotland prefer to calculate the energy benchmark by heated volume, and this is normalised by assuming a standard ceiling height of 2.5 m. As can be seen in Table 2, the average consumption of an NHSScotland smaller building is almost 3 times the recommended good practice for a small office. However, as mentioned above, there is a widespread in consumption between individual buildings, with the bulk of the audited buildings (60%) having a consumption of between 0.34 and 0.57 GJ/m^3 and a median of 0.45 GJ/m^3. Even so, this is higher than the recommended consumption according to BRE's guidelines for energy use in offices (BRE, 1999).

In a previous effort to generate a benchmark for NHSScotland smaller buildings, including C5 buildings, the Carbon Trust based their Good Practice benchmark of 0.35 GJ/m^3 for NHSScotland (Le Breton, 2005) on the consumption of the best energy performing 30% for existing buildings, and the consumption of the best 25% for new and refurbished buildings (Table 3).

Table 3
Comparison of benchmarks

Data source	Energy consumption (GJ/m^3)
PEFEX audit sample[a] (2000/2001)	
Median value	0.444
Best 25% of sample audit	<0.351
Best 25% of sample audit	<0.275
Carbon Trust audit (2003/2004)	
Median value	0.417
New/refurbished buildings (best 25%)	<0.250
Existing buildings (best 30%)	<0.350
Recommended benchmarks	
Carbon Trust	
New/refurbished buildings	0.250
Existing buildings	0.350
BRE small offices	0.160

[a]Includes existing and new buildings.

Due to the lack of a sufficiently large and robust database on new and refurbished buildings in 2004, the Carbon Trust's comparisons for new and refurbished buildings are based on the 1st Quartile consumption value for 2003/2004. In comparison, only 3 of the buildings listed as new build in the sample audit used for this study are in the top 20% best energy consumers. Five of the new builds in the sample audit can be found among the bottom 20% of poorest energy consumers.

It is clear, then, that the Carbon Trust benchmark, which is based on current best performance, is significantly higher than the comparable BRE benchmark that is based on good practice for small offices. Thus, an alternative good practice benchmark for NHSS smaller buildings may be required in order to better highlight poor energy performance and to offer good practice targets.

2.3. Creating a NHSS good practice energy benchmark

Performance benchmarks have been established as a successful tool in raising awareness and improving building performance by offering a comparative standard to staff and building/energy managers alike. However, such benchmarks are more likely to be accepted by management and staff, if it can be demonstrated that they are based on a very large sample or on accepted good practice. In the case of C5 buildings, neither the UK national healthcare benchmark created for larger acute hospitals nor the NHS energy-efficiency key guidance document, Encode 1, takes account of these smaller buildings, and there were, therefore, no models for these. Similarly, there appear to be no reports on this topic in the relevant literature.

However, Murray et al. (2004) made a comparison between C5 buildings and small office complexes for the purpose of benchmarking because of the similarities in building layout, usage patterns and occupancy levels. More recently, the 1st draft of Encode 3 adopted this view and it is deemed reasonable to compare typical baselines for annual energy consumption with that of small office buildings and to base a C5 good practice benchmark on the equivalent small office building benchmark (Table 3) provided by the Building Research Establishment (BRE, 1999).

While there are significant similarities between C5 buildings and small office complexes, there are also some differences that need to be taken into consideration. Most people attending health centres for treatments are unwell, which may mean that their bodily defences are lowered, making them vulnerable to chills, etc. Patients may, at times, be in various states of undress depending on the type of examination. For this reason heating in a health building should be 23 °C, i.e. 3 °C higher than the minimum recommended for office buildings, and any benchmark will need to take this into consideration. This 3 °C increase in temperature is in keeping with NHS and its use of 18.5 °C as the base degree day temperature as opposed to the standard 15.5 °C (PEFEX, 2005).

Lowering a room thermostat by 1 °C will save between 8% and 10% of heating consumption; the opposite is also true (BRE, 1996). To highlight this point and using the BRE model, Peter Iles, Principal Consultant with BRE Environment, puts it as simply as "for a semi-detached house with gas central heating, and a demand temperature in zone 1 (the living area) of 21.3 °C, the space heating energy consumption is 50.1 GJ/yr. Decreasing the demand temperature to 20.3 °C gives a space heating energy consumption of 45.0 GJ/yr" (Iles, 2006).

By setting the room temperatures 3 °C higher than the recommended temperature of 20 °C, an allowance can be made in the benchmark. Using the lower estimated percentage difference in this case, the allowance would be $3 \times 8\% = 24\%$. In combination with the 0.16 GJ/m^3 good practice benchmark for small offices (BRE, 1999), this equates to a corrective element of 0.04 GJ/m^3 and gives a benchmark of 0.20 GJ/m^3 (and a typical baseline of 0.30 GJ/m^3), which is much lower than the Carbon Trust's recommended benchmark for C5 buildings, especially for existing buildings.

It could be argued that a single benchmark may not be suitable for different parts of the country. For instance, the North-east is generally seen as colder than the milder south. However, the difference in degree days between the North-east and the South-west of Scotland was only 5% and the difference between the East of Scotland and the West was only 2%, which would mean that the 0.20 GJ/m^3 figure would be varied by 0.010 and 0.004 GJ/m^3, respectively. These differences are seen as negligible. It was also noted that energy consumption did not correlate with geographical area; therefore a benchmark of 0.20 GJ/m^3 is considered suitable as a national target.

3. Discussion and conclusion—a challenging but realistic benchmark?

A good benchmark target should be achievable, otherwise it will not be adopted, and it must be considered whether the good practice target of 0.20 GJ/m^3 proposed by this project is realistic.

The process of benchmarking can be conducted internal to an organisation or it can include comparison with other organisations (Geerlings et al., 2006), particularly at the evaluation and target-setting stages. Hanman (1997) describes this external comparison as learning best practice from benchmark partners and it can be argued that the decision whether to include the element of external comparison via industry best practice depends on the overall strategic aim that an organisation sets for its benchmarking process. If the aim is to simply reduce the energy consumption, than using a value based on present performance within the industry may be sufficient. If, however, the aim is to be as efficient as possible, then this may give a false target: using values attained from the top performers within an industry provides an idea of what may be achievable for the rest of the industry. However, it does not allow inferring how efficient the relative top performers are to begin with; the top percentage could simply be less inefficient than the rest.

Therefore, it is suggested that an energy benchmark derived from proven good practice for similar buildings and operations will help NHSScotland to become more energy efficient in the longer term. In the short term, it may be easier to attain the Carbon Trust benchmark of 0.35 GJ/m^3. However, the long-term goal must be to reduce energy consumption to the benchmark of 0.20 GJ/m^3. In the terms of the EU EQUIP-Consortium (2000a, b), this would mean that the energy-efficiency measures and policy of the NHSScotland, along with their benchmark targets, should progress from an interim milestone of internal benchmarking to the higher levels of benchmarking that include cross-sector comparison and adoption of operating practice.

If it is considered that many of the C5 buildings are planned to undergo upgrading as part of routine building maintenance (due to the average age of C5 buildings), then significant improvements in energy should be relatively easily achievable. The interim target of 0.35 GJ/m^3 may thus be achieved in the nearer future. However, the longer-term target of 0.20 GJ/m^3 may present a great challenge to NHSScotland, and it is suggested that its achievement would depend not only on the installation but, crucially, also on the efficient use of efficient heating, lighting and electrical equipment by management and staff in NHSScotland health buildings: anecdotal evidence revealed during this research (Box 1), in combination with the aforementioned poor correlation between energy consumption and building fabric, suggests that much of the variation in energy consumption in NHSScotland buildings is due to daily operational routines. Koomey et al. (1996) found that many staff believe that it is acceptable to leave "energy star compliant" equipment switched on or in standby mode, and the current study found this still to be the case in many health centres. This suggests a need for further research in the area of staff and management awareness, preparedness and ability to change working practices (currently investigated by this project).

Overall, it is worth noting that the targets for improvements suggested here are in line with other sectors and the UK as a whole: the idea of a '2000 Watt' Society put forth by Eidgenössische Technische Hochschule Zürich (Zimmermann et al., 2005) appears worth pursuing for a sustainable energy future. This equates to around

Box 1

Anecdotal evidence on the lack of correlation between energy consumption and infrastructure.

With such a disparity in energy use it could be inferred that buildings vary greatly in their constructions. However, this is not the case. Most NHSScotland health centres were built since 1945 and many of these built in the 1960s and 1970s. Most comprise of facing brick on lightweight autoclaved cellular concrete (ACC) block with 50 mm cavity. Most buildings have a pitched tiled roof. There are differences in types of glazing, but as glazing represents a small fraction of the heat losses from buildings this would not make such a huge difference in the overall heat loss from these types of buildings.

Only 3 of the buildings listed as new build in this study's sample audit were in the top 20% best energy consumers. Five of the new builds in the sample audit were found among the bottom 20% of poorest energy consumers.

Most of the buildings visited had reasonably efficient boiler systems. Case Study C5/161, however, had problems with the heating system when the audit was being conducted. This resulted in it having by far the highest energy consumption. The heating problem had apparently been dealt with, but staff at the Centre felt that not much had changed. The building was too hot in summer and was cool in winter. A large array of desk and free-standing cooling fans was noted on the visit. C5/161 has the main wall facing south with a large area of single glazing, which would not be a problem if staff could open windows on warm sunny days. However, because of the possibility of sensitive information being overheard during consultation, windows are usually kept shut, especially on the ground floor. This can result in overheating during the summer and creates the need for cooling fans. This contributes further to the discomfort of staff of C5/161. Although this is probably an exceptional case, it still highlights the way that the operation of the building can severely affect the energy consumption.

It was of interest at the outset that the health centre with smallest area, C5/16, is one of the higher consumers per square metre. The largest building, C5/126, at 4461 m^2 and 10812 m^3 used the most amount of energy, but, at 38.9 GJ/100 m^3, was also in the top 33% of energy performers by volume. This might suggest an ''economy of scale'', that larger practices are more energy efficient than much smaller buildings, but the spread of size throughout the sample does not support this:

- Health centre C5/14 is slightly larger than the average at 1360 m^2 and 3332 m^3 and, consuming 0.39 GJ/m^2 or 15.9 GJ/100 m^3, is overall the most energy efficient of the entire sample, even though C5/70, a very small building in comparison, uses less energy per volume.
- Other buildings in the sample such as C5/173, C5/117 and C5/99, which are near the average size, are within close reach of the suggested benchmark.

17,520 kWh per person per year. Currently in the UK energy consumption is 31,313 kWh per person per year, which is 44% above the '2000 Watt' sustainability threshold. The percentage of reduction required to achieve this threshold in the UK is close to that required by a large number of NHSScotland premises to meet the longer-term benchmark of 0.20 GJ/m^3.

Finally, it appears that energy efficiency of small-scale health buildings is largely overlooked by estate/energy managers, internationally, and the development of good practice benchmarks, as described here, may be a good starting point in order to achieve improved energy efficiencies and reduce the impact of health services on global warming and energy-related pollution.

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