Review of opportunities for improved carbon savings from spend on education buildings

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1 Opportunities for improved carbon savings from spend on education buildings

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1 Executive Summary

Building Schools for the Future – this secondary schools capital investment programme will apply minor refurbishment to 15% of secondary schools, major refurbishment to 35% and will rebuild 50%. There are 3436 secondary schools.

Minor refurbishments – proposed for BSF for 15% of secondary schools. Applying low cost measures to these 515 secondary schools could save 4.8-5.5ktC/year for an overall upfront cost of £4.5m – 5m. Payback within 5 years.

Major refurbishments – We assume that a number of elements will be upgraded as a matter of course within the major refurbishment – either because elements have reached the end of their functional life, or because this will be a requirement to comply with Building Regulations and BREEAM. 35% of secondary schools (1202 number) will undergo major refurbishment through BSF.

School buildings undergoing major refurbishments will be expected to meet the Schools BREEAM 'very good' standard. In order to achieve this stretching standard, existing schools will need to achieve credits under the 'energy' score. This is based on a betterment of compliance with the Building Regulations for new build. We therefore assume that major refurbishments will have to install maximum cost effective energy efficiency in order to achieve the BREEAM 'very good' score.

New build schools – We assume that rebuilt schools will reach the maximum cost effective energy efficiency in order to comply with Building Regulations. 50% of secondary schools will be rebuilt within BSF, which is 1718 schools.

Microgeneration - Applying biomass boilers and micro wind to 10% of all rebuilds and major refurbishments (292 schools) would save 14.6ktC for a cost of £45m. Payback within 25years without grants.

Total carbon saving proposed from energy efficiency and microgeneration in secondary schools is 19.4-20.1tC/year for capital cost of £49.5-50m.

Primary Capital Programme - this proposes to rebuild, remodel or refurbish 50% of the primary schools. Details are not yet developed, therefore we propose that for this exercise the scheme will apply major refurbishment to 25% of primary schools, and rebuild another 25% of primary schools. There are 17861 primary schools in England.

Major refurbishments – We assume that a number of elements will be upgraded as a matter of course within the major refurbishment – either because elements have reached the end of their functional life, or because this will be a requirement to comply with Building Regulations and BREEAM. 25% of primary schools (4465 schools) will undergo major refurbishment through PCP.

New build schools – We assume that rebuilt schools will reach the maximum cost effective energy efficiency in order to comply with Building Regulations. 25% of primary schools (4465 schools) will be rebuilt within PCP.

Microgeneration - Applying biomass boilers and micro wind to 10% of all rebuilds and major refurbishments (893 schools) would save 8.7ktC/year for a capital cost of £49m. Payback within 30years without grants.

Total Carbon Saving from energy efficiency and microgeneration measures proposed above is 8.7ktC/year for a capital cost of £49m

2 Introduction

The purpose of this research project was to assist the Sustainable Development Commission by gathering the evidence base to show how DfES spend on energy efficiency and renewables in new school buildings and refurbishments could be used to improve whole-life costs, reduce schools' carbon footprint, and reduce the likelihood of complications in planning approvals.

In particular the Commission wished to obtain information that would help DfES and HMT arrive at spending decisions, during the next Comprehensive Spending Review period, that deliver greater energy efficiency and carbon savings within the *Building Schools for the Future* programme and other major programmes.

To achieve these aims the research has followed two main themes:

1) An assessment of the current energy use / carbon emissions performance of the existing primary and secondary school estates in England so as to establish the base from which future savings could be made.

2) Mathematical modelling of the costs/benefits afforded by the potential savings measures that could be applied in the event that the above schools were to be replaced of refurbished.

The approaches are outlined as follows and described in more detail in subsequent sections of the report.

2.1 Assessment of current performance.

Using the DfES energy returns data for 2000 - 2003[1] the total energy spend and trends in consumption and carbon emissions over recent years were assessed. (See section 3).

The data set was then used to benchmark the performance of schools by type (primary/secondary) and by the age of the facility. Five main school age groupings[2] were analysed – pre 1919 – 1919-1939 – 1946-1966 – 1967-1976 & 1976 onwards, a limited amount of analysis was also possible for schools built post 1995. (See section 4).

The Benchmark analysis was also used to identify example sites that would be used later as case studies to verify the results of the mathematical modelling. Some of these examples have benefited from previous energy surveys (generally to identify no cost and low cost improvement measures) and analysis of the findings from that group is presented in section 5.

[1] 2003 is the latest available complete data set and represents the performance of approximately 61.6% of primary schools and 58.3% of secondary schools in England.
[2] Age groupings recorded within DfES Asset Management Plans.

2.2 Mathematical modelling

Mathematical modelling was used to determine the costs and benefits indicated by the application of a range of carbon saving measures.

The primary modelling was carried out in accordance with the methodologies set out in DfES Building Bulletin 87 and this was checked against results obtained using the London Renewables – Toolkit for planners, developers and consultants.

The analysis also employed the Simplified Building Energy Model (SBEM) which has been developed in response to the Energy Performance of Buildings Directive. The use of SBEM was determined by the requirement to also check the effect of various carbon reduction measures on the BREEAM rating. The BREEAM 2006 scheme scores, in the energy section, are related to the SBEM calculation of CO_2 emissions and hence carbon.

The SBEM tool also has facilities for calculating the effect of the implementation of renewables. As many local authorities are seeking to embrace the 10% renewable obligations, the tool was used to check the effect of such implementation.

Models were created for primary and secondary schools and both were typical in terms of size and construction to those found in the existing estate.

3 Analyses of current overall energy consumption in schools

The following sections provide an analysis of the schools energy data collected by the DfES. The data-base therefore represents 61.6% of primary schools and 58.3% of secondary schools or 61.1% of the estate overall. It is assumed that the returns within the data-base are representative of the estate as a whole and the results of this analysis can therefore simply be factored to determine the overall results.

3.1 Source data

- The source data used in the analysis is the DfES energy returns for schools in England 2003 (this is the latest available complete data set).
- The data-base contains returns for 11,000 primary and 2,004 secondary schools.
- There are a total of 17,861 primary schools and 3,436 secondary schools in England.

Table 1 DfES overall school estate statistics 2003

	Data-base sample	**Whole Estate**
Total fossil fuel consumption	5,399,122MWh	8,836,533MWh
Total electricity consumption	1,425,460MWh	2,332,990MWh
Total energy consumption	6,824,582MWh	11,169,523MWh
Total carbon emissions	446,710tonnes	761,022tonnes
Total expenditure	£156,060,256	£255,417,766
Electricity carbon emissions	167,167tonnes	274,045tonnes
Fossil fuel carbon emissions	279,543tonnes	486,977tonnes
Total floor area	34,603,161m^2	56,633,651m^2
Area energy consumption[3]	197.22kWh/m2/yr	197.22kWh/m2/yr
Area carbon emissions	13.43kgC/m2/yr	13.43kgC/m2/yr
Area electricity cost	£2.20/m^2	£2.20/m^2
Area fossil fuel cost	£2.31/m^2	£2.31/m^2
Average unit electricity cost	5.15p/kWh	5.15p/kWh
Average unit fossil fuel cost	1.65p/kWh	1.65p/kWh

[3] This figure represents an overall average and does not relate directly to the figures shown in the chart on the following page which take account of the fuel mix on sites (e.g. some school may be all electric).

3.2 Trends in energy usage

The following chart shows the trend in estate-wide energy consumptions and carbon emissions over the period 2000 – 2003. A rise followed by a steady fall is indicated in the case of fossil fuel consumption, whilst electricity usage has been steadily increasing. Of particular note is the rise in electricity consumption. The chart indicates that the specific electricity consumption (kWh/m2/yr) has increased by 32% in the period 2000-2003.

In 1998 when a previous benchmarking exercise was undertaken[4] the benchmark values for electricity and fossil fuel were approximately 29kWh/m2/yr and 173kWh/m2/yr respectively. Comparing these earlier values with the latest year shows the electricity usage has increased by 64% whilst fossil fuel has reduced by 6%.

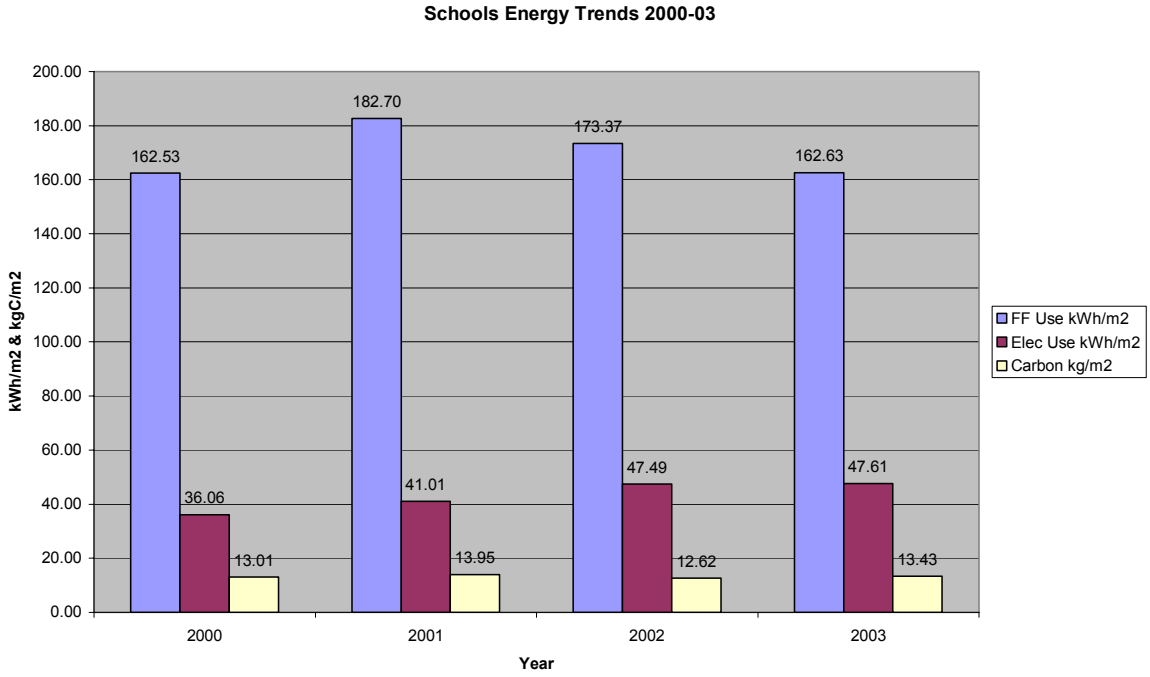


Figure 1 Schools Energy Trends 2000-03

[4] Energy Efficiency Best Practice Programme – Energy Consumption Guide 73

4 Benchmark analyses of energy consumption in different school types

The analysis which is detailed in Appendix 1, uses the above mentioned source data to establish benchmarks for the energy consumption and associated carbon emissions for different school types. Results are shown for primary and secondary schools (with and without pools) for five building age ranges.

Limited data is available for the most recently constructed schools and only the results for one building group (primary schools constructed post 1995) are presented. These results form part of the post 1976 construction group.

4.1 Assumptions used in the analysis

Age of buildings – Schools, unless recently constructed, rarely contain buildings with a single age grouping. Many schools have building extensions and early founded schools may contain buildings of many different ages. The limitation of the energy data available means that it is generally not possible to analyse the separate consumptions of buildings within a school. For these reasons the analysis uses sample data from schools only where at least 60% of the built area corresponds to the age group in question and it is assumed that the results from these schools will be representative of the group.

Condition of buildings – The data does not facilitate the making of any allowance for refurbishment that may have been applied to individual schools within the sample and again it is assumed that all schools in the sample will be representative of the group.

4.2 Output from analysis

The analysis of each school type shows the distribution of:

- Area carbon emissions kgC/m2/yr
- Area energy consumption kWh/m2/yr
- Area cost £/m^2/yr

for electricity, fossil fuel and total energy. It then uses the performance in each quartile of the distribution to assess the typical or benchmark performance for the group. Here it is assumed that the 2nd quartile, i.e. the performance achieved or bettered by 50% of the buildings in the group, represents typical performance. This is in line with previous school benchmarking assessments. The 2nd quartile results are highlighted on the pages in Appendix 1.

Details of the sample data for each group are also given.

The individual group analyses are followed by summary charts comparing the performance between the groups.

4.3 Benchmarking analysis findings

Overall the above analysis indicates a high degree of consistency in the carbon emissions from schools of all types and ages. The average carbon emissions equate to 13.43kgC/m2/yr. Reference to the charts in Appendix 1 shows that the variations of typical results (2nd quartile schools without pools) from the average value are not great.

- Primary schools (no pool) carbon emissions – 13.4 – 14.4kgC/m2/yr
- Secondary schools (no pool) carbon emissions – 12.3 – 14.1kgC/m2/yr

Greater variations are displayed in schools with pools. Whilst to some extent this may be explained by the relative small size of the sample in each group and the fact that no account has been taken of the pool size relative to the remainder of the school, further analysis would be required before meaningful conclusions could be drawn in respect of this group. This is particularly true of the primary schools with pools where some lower emissions are indicated than for the group without pools.

- Primary schools (with pool) carbon emissions – 12.9 – 14.9kgC/m2/yr
- Secondary Schools (with pool) carbon emissions – 15.2 – 20.4kgC/m2/yr

The summary charts (schools without pools – Appendix 1) indicate a tendency for carbon emissions due to fossil fuel to decrease as the building age decreases whilst conversely carbon emission due to electricity consumption increase. This is perhaps as would be expected – fossil fuel requirements certainly will decrease with improving standards if building insulation and electricity requirements are probably higher in new buildings with increased use of equipment such as computers.

This decreasing dependence on fossil fuel combined with the increasing reliance on electricity contributes to the overall levelling of carbon emissions. A summary of the benchmark values obtained are given in the following tables:

Table 2 Summary Benchmarks Primary School (No Pool)

Primary school (no pool)	**Pre 1919**	**1919-1939**	**1946-1966**	**1967-1976**	**Post 1976**	**Post 1995**
kgC/m2/yr	14.4	13.6	13.7	13.8	13.4	13.4
kWh/m2/yr	194.2	195.2	193	190.1	185.8	174.1
£/m^2/yr	4.9	4.6	4.8	4.8	4.8	4.9
Typical overall school values						
Floor area (m^2)	1316	1880	1692	1469	1489	1893
Carbon emissions tonnes per annum	19.0	25.6	23.2	20.3	20.0	25.4
Energy consumption kWh per annum	255567	256883	253988	250172	244513	229116
Energy cost £ per annum	6448	6054	6317	6317	6317	6448

Table 3 Summary Benchmarks Primary School (with pool)

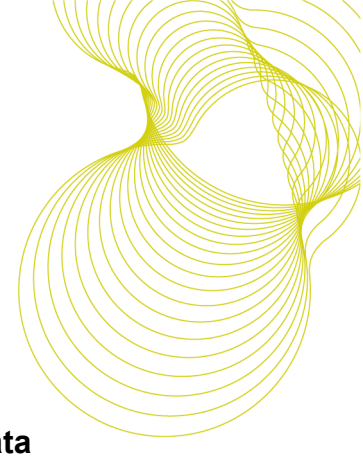
Primary school (with pool)	Pre 1919	1919-1939	1946-1966	1967-1976	Post 1976
kgC/m2/yr	14.4	14.9	13.2	13.1	12.9
kWh/m2/yr	175.8	213.8	171	177.3	186.5
£/m^2/yr	4.9	5	4.7	4.8	4.8
Typical overall school values					
Floor area (m^2)	1257	2047	1776	1569	1585
Carbon emissions tonnes per annum	18.1	30.5	23.4	20.6	20.4
Energy consumption kWh per annum	231353	281361	225036	233327	245434
Energy cost £ per annum	6448	6580	6185	6317	6317

Table 4 Summary Benchmarks Secondary School (no pool)

Secondary school (no pool)	Pre 1919	1919-1939	1946-1966	1967-1976	Post 1976
kgC/m2/yr	12.9	12.3	13	13.2	14.1
kWh/m2/yr	186.4	170.0	177.4	183.3	190.4
£/m^2/yr	4.9	4.4	4.6	4.8	5
Typical overall school values					
Floor area (m^2)	7750	8233	8538	7664	8607
Carbon emissions tonnes per annum	100.0	101.3	111.0	101.2	121.4
Energy consumption kWh per annum	1444600	1399610	1514641	1404811	1638773
Energy cost £ per annum	37975	36225	39275	36787	43035

Table 5 Summary Benchmarks Secondary School (with pool)

Secondary school (with pool)	Pre 1919	1919-1939	1946-1966	1967-1976	Post 1976
kgC/m2/yr	20.4	16.2	15.2	16.8	16.1
kWh/m2/yr	282.8	222.7	206.0	232.8	237.3
£/m^2/yr	7.1	5.6	5.2	6	6
Typical overall school values					
Floor area (m^2)	8554	8666	8467	9815	8917
Carbon emissions tonnes per annum	174.5	140.4	128.7	164.9	143.6
Energy consumption kWh per annum	2419071	1929918	1744202	2284932	2116004
Energy cost £ per annum	60733	48530	44028	58890	53502



5 Evaluation of low cost measures from past school survey data

In order to help assess the role of energy efficiency in reducing carbon emissions in schools the recommendations from a sample of previous school surveys were analysed to determine the likely impact and replication potential afforded by low cost refurbishment and management measures. The findings, which are presented in the following table, are used to inform the modelling of possible improvement measures detailed in the next section.

Table 6 Analysis of Carbon Savings (School Surveys)

Analysis of carbon savings potential in school surveys		Totals	Total kgC Saved	Total kWh	Total £ Saved	Total Implementation Cost £	Average Payback Period yrs	% of sites requiring recommendation	Site level cabon saving impact potential kgC/m²/yr
Base data	m^2	123759							
	kgC (e)	759716							
	kgC (ff)	1393563							
	kgC (total)	2153279							
	Existing kgC/m^2/yr	17.40							
Improvement measure									
Lighting	Replace T12 lamps with T8		7045	59871	2455	1890	0.77	46.7%	0.12
	Replace tungsten lighting with CFL		1659	14745	531	900	1.69	26.7%	0.05
	Fit automatic lighting controls generally		51527	436998	19122	44150	2.31	66.7%	0.62
Office equipment	Install timeswitches to control office equipment, computers & vending machines		5493	46547	2170	650	0.30	20.0%	0.22
Heating & ventilating & HWS	Introduce passive ventilation		1495	127450	2000	2000	1.00	6.7%	0.18
	H & V control improvements fossil fuel		63745	1213719	15169	47750	3.15	80.0%	0.64
	H & V control improvements electricity		4085	35000	1437	2250	1.57	13.3%	0.25
	HWS control improvement		5577	77200	1550	1800	1.16	20.0%	0.23
	Upgrade space heating systems		10882	210000	2583	7000	2.71	6.7%	1.32
	Insulate boilerhouse pipework/fittings		17668	337313	4347	10465	2.41	73.3%	0.19
Building fabric	Draft proofing windows		4071	78551	909	100	0.11	13.3%	0.25
	Draftproof external doors		4925	95040	1253	2080	1.66	20.0%	0.20
Process	Fit "Sava-Watt" adaptors to fridges, freezers, chilled appliances		2700	22800	1043	1794	1.72	13.3%	0.16
Swimming pool	Swimming pool cover								
	Fossil Fuel		4145	80000	978	3250	3.32	6.7%	0.50
	Simming pool upgrade controls								
	Electricity		3518	30000		3250	2.48	6.7%	0.43
	Total Savings kgC		**180,282**						
	Total Savings kWh			**2865234**					
	Total Savings £				**56858**				
	Total Implementation Cost £					**129329**			

Carbon emissions after low cost improvement measures kgC/m^2/yr **15.94**

Overall results low cost capital measures

kgC/m^2/yr saved	**1.46**
% C Saved	**8.37%**
Payback Period yrs.	**2.27**

15 Opportunities for improved carbon savings from spend on education buildings

Analysis of carbon savings potential in school surveys		Totals	Total kgC Saved	Total kWh	Total £ Saved	Total Implementation Cost £	Average Payback Period yrs	% of sites requiring recommendation	Site level cabon saving impact potential kgC/m^2/yr
Management measures	Develop an Energy Policy Fossil Fuel		10422	201124	3161			13.3%	0.63
	Develop an Energy Policy Electricity		14612	114437	4413			20.0%	0.59
	Good Housekeeping Practices Heating		57305	1012827	15124			53.3%	0.87
	Good Housekeeping Practices Lighting		59464	304825	13452			73.3%	0.66
	Good Housekeeping Practices General		26891	147178	11170			46.7%	0.47
	Switch off computers when not in use		6281	56442	2432			40.0%	0.13
	Good Housekeeping Practices Pool		3845	74000	1000			6.7%	0.47
	Total Savings kgC		**178,820**						
	Total Savings kWh			**1910833**					
	Total Savings £				**50752**				

Carbon emissions after management measures kgC/m^2/yr **15.95**

Overall results management measures

kgC/m^2/yr saved **1.44**

% C Saved **8.30%**

Carbon emissions after low cost improvement &management measures kgC/m^2/yr **14.50**

Overall results low cost improvenment &management measures

kgC/m^2/yr saved **2.90**

% C Saved **16.68%**

By reference to the above tables it will be seen that the carbon emission performance of the survey sample was slightly worse than the typical performance of schools overall (i.e. 17.4kgC/m2/yr survey sample – compared to 13.42kgC/m2/yr all schools discussed above). Thus the performance for all schools is 77% of the survey sample. This is as might be expected in as much as schools seeking surveys to improve their performance are likely to be experiencing poor performance.

The following table indicates the savings that might be achieved across the whole school estate, through management and low cost refurbishment measures, assuming that it is possible to achieve savings equivalent to 77% of those indicated above:

This assumption has also been applied to the calculations for minor refurbishments in the next section.
Analysis of carbon savings investments

Table 7 Analysis of low cost carbon savings across the schools estate

Savings	**Minor refurbishments**	**Management measures**	**Total**
kgC/m2/yr	1.12	1.11	2.23
kWh/m2/yr	17.82	11.89	29.72
£/m2	0.35	0.32	0.67
Typical primary school			
tC	1.73	1.71	3.44
kWh	27514	18358	45872
£	540	494	1034
Typical secondary school			
tC	9.60	9.51	19.11
kWh	152788	101944	254732
£	3000	2743	5743

5.1 Description of model and approach

Mathematical modelling was used to determine the costs and benefits indicated by the application of a range of carbon saving measures.

The primary modelling was carried out in accordance with the methodologies set out in DfES Building Bulletin 87 and this was checked against results obtained using the London Renewables – Toolkit for planners, developers and consultants.

The analysis also employed the Simplified Building Energy Model (SBEM) which has been developed in response to the Energy Performance of Buildings Directive. The use of SBEM was determined by the requirement to also check the effect of various carbon reduction measures on the BREEAM rating. The BREEAM 2006 scheme scores, in the energy section, are related to the SBEM calculation of CO_2 emissions.

The BREEAM analysis within this assessment analyses only the marginal effect of the various energy/carbon improvement measures. It assume that the balance of the measures which go towards the overall BREEAM rating are achieving a score of 50 points (See Appendix 3 for BREEAM rational) without the energy element, which from experience is typical of new school buildings.

The SBEM tool also has facilities for calculating the effect of the implementation of renewables. As many local authorities are seeking to embrace the 10% renewable obligations, the tool was used to check the effect of such implementation.

Models were created for primary and secondary schools and both were typical in terms of size and construction to those found in the existing estate.

The full results can be found in appendix 2 and a summary can be found in the following 2 tables including a measure of the effect on the BREEAM rating.

New Build		Primary					Secondary				
		Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Corresponding BREEAM score for credit E1 (2006 scheme)	Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Corresponding BREEAM score for credit E1 (2006 scheme)
		Primary	Primary	Primary	Primary	Primary	Secondary	Secondary	Secondary	Secondary	Secondary
Renewables	biomass boiler	7518	1.28	23	11	14	7648	1.3	13	6	13
	solar thermal	237	0.17	52	26	2	241	0.2	52	26	2
	PVs	154	0.08	63	31	2	156	0.1	62	31	2
	wind turbine	1224	0.66	30	15	6	947	0.4	25	13	5
	ground source heat pumps	3644	0.11	See cost notes		11	3707	0.1	See cost notes		10

Figure 2 Summary New Build

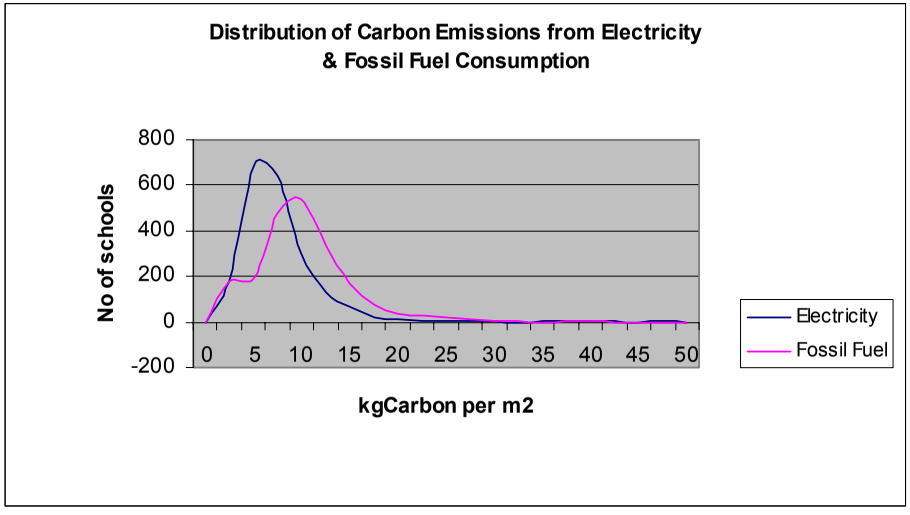
Refurbishment	Primary					Secondary				
	Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Corresponding BREEAM score for credit E1 (2006 scheme)	Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Corresponding BREEAM score for credit E1 (2006 scheme)
Renewables	Primary	Primary	Primary	Primary	Primary	Secondary	Secondary	Secondary	Secondary	Secondary
biomass boiler	**5263**	**0.90**	**22.9**	**11.5**	**13**	**5353**	**0.91**	**13**	**6**	**13**
solar thermal	**166**	**0.12**	**52.1**	**26.0**	**0**	**169**	**0.12**	**52**	**26**	**2**
PVs	**108**	**0.06**	**62.5**	**31.3**	**0**	**109**	**0.06**	**62**	**31**	**2**
wind turbine	**857**	**0.46**	**30.4**	**15.2**	**2**	**663**	**0.27**	**25**	**13**	**5**
ground source heat pumps	**2551**	**0.08**	**See cost notes**		**10**	**2595**	**0.08**	**See cost notes**		**10**
Minor refurbishments										
Lighting- replace T12 with T8 and/or compact fluorescesnt, average efficacy 65lumens per circuit watt.	**201**	**0.11**	**0.9**	**N/A**	**N/A**	**205**	**0.11**	**0.9**	**N/A**	**N/A**
Lighting controls – occupancy sensing to corridors and toilets (65lm/cct watt).	**1347**	**0.72**	**2.1**	**N/A**	**N/A**	**1370**	**0.73**	**2.1**	**N/A**	**N/A**
Timeswitch control of office equipment, vending machines, computers, etc.	**142**	**0.08**	**0.3**	**N/A**	**N/A**	**145**	**0.08**	**0.3**	**N/A**	**N/A**
Introduce passive ventilation.	**393**	**0.16**	**4.2**	**N/A**	**N/A**	**400**	**0.17**	**4.2**	**N/A**	**N/A**
H&V controls improvements typically weather compensation, TRVs and optimum start and minor system upgrades.	**2421**	**1.00**	**2.1**	**N/A**	**N/A**	**2463**	**1.02**	**2.1**	**N/A**	**N/A**
HWS controls and efficiency improveme	**142**	**0.06**	**1.0**	**N/A**	**N/A**	**145**	**0.06**	**1.0**	**N/A**	**N/A**
Insulate boilerhouse pipework/fittings.	**465**	**0.19**	**1.9**	**N/A**	**N/A**	**473**	**0.20**	**1.9**	**N/A**	**N/A**
Draught proofing.	**242**	**0.10**	**0.6**	**N/A**	**N/A**	**246**	**0.10**	**0.6**	**N/A**	**N/A**
Controls for fridges, freezers & chilled appliances.	**71**	**0.04**	**1.6**	**N/A**	**N/A**	**72**	**0.04**	**1.6**	**N/A**	**N/A**
Major Refurbishment										
1. Lighting – replace T12 with T5 throughout –average efficacy 100 lumens per circuit watt	**3518**	**1.87**	**195.8**	**N/A**	0	**3579**	**1.90**	**198.4**	**N/A**	0
2. Lighting controls – dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**3812**	**2**	**4.7**	**N/A**	0	**3877**	**2**	**4.2**	**N/A**	0
3. Lighting controls – occupancy sensing to corridors and toilets plus dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**4887**	**3**	**5.3**	**N/A**	0	**4971**	**3**	**4.8**	**N/A**	0
4. Upgrade heating – replace pre ECA standard boilers with post ECA standard	**29417**	**12**	**3.9**	**N/A**	0	**23860**	**10**	**3.3**	**N/A**	0
5. Single glazing replaced by 2005 specification double glazing (also assumes draughtproofing improvement)	**8503**	**4**	**88.9**	**N/A**	0	**8053**	**3**	**68.9**	**N/A**	0
6. Roof insulation – flat, minimal insulation replaced with 2005 regs compliant	**26192**	**11**	**61.4**	**N/A**	0	**9743**	**4**	**51.2**	**N/A**	0
7. Cavity wall insulation, blown balls, full fill	**7819**	**3**	**9.6**	**N/A**	0	**24058**	**10**	**7.8**	**N/A**	0
8. Post war - cavity wall insulation added, boiler and heating upgraded, lighting T5 and controls, double glazing.	**26554**	**11**	**38.3**	**N/A**	0	**35832**	**16**	**37.8**	**N/A**	0
9 As 8 plus new flat roof and insulation	**52021**	**22**	**42.1**	**N/A**	11	**49011**	**21**	**35.6**	**N/A**	8
10 Pre- war (1945) Boiler and htg upgraded, lighting T5 and controls and double glazing. (Secondary includes roof insulation)	**13956**	**6**	**42.5**	**N/A**	0	**6987**	**3**	**39.0**	**N/A**	0
11 As 10 plus pitched roof insulation increased to 250mm	**19535**	**8.42**	**36.9**	**N/A**	7	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

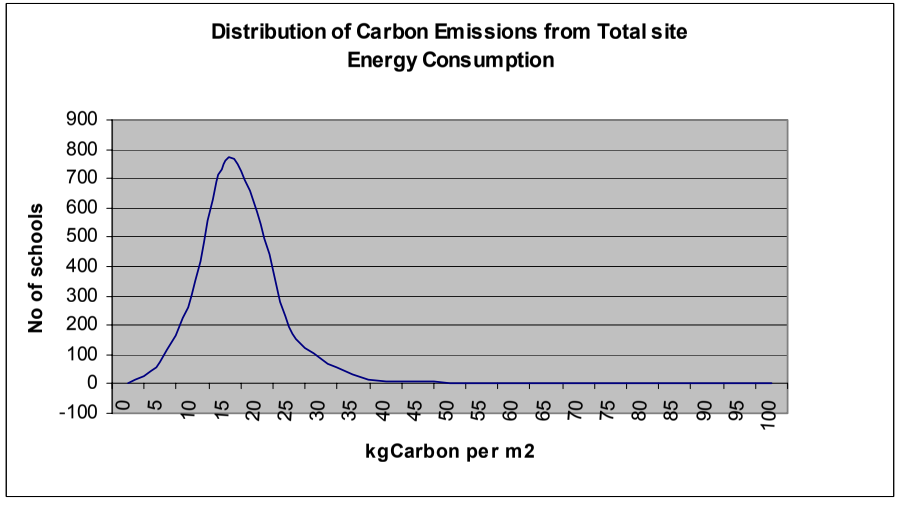
Figure 3 Summary Refurbishment

Appendices

Appendix 1 – Results of annual benchmarking analysis

Primary School (no pool) – built pre 1919

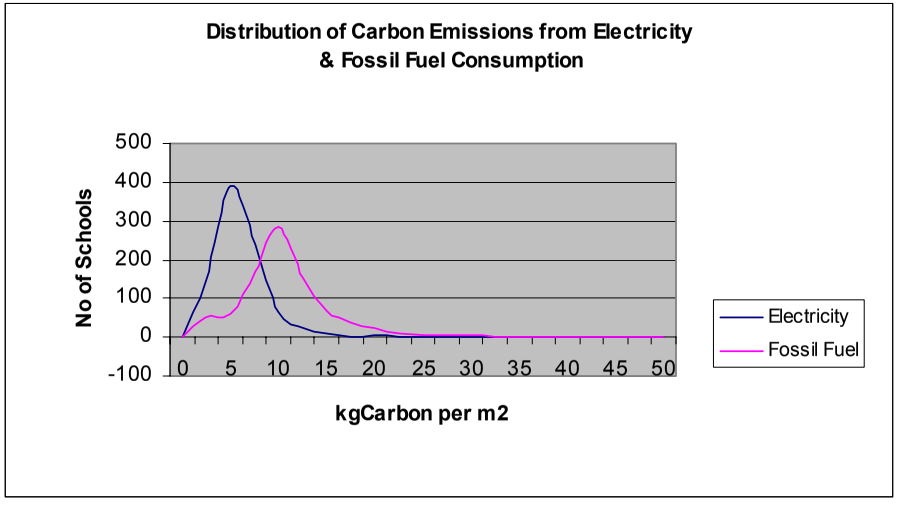


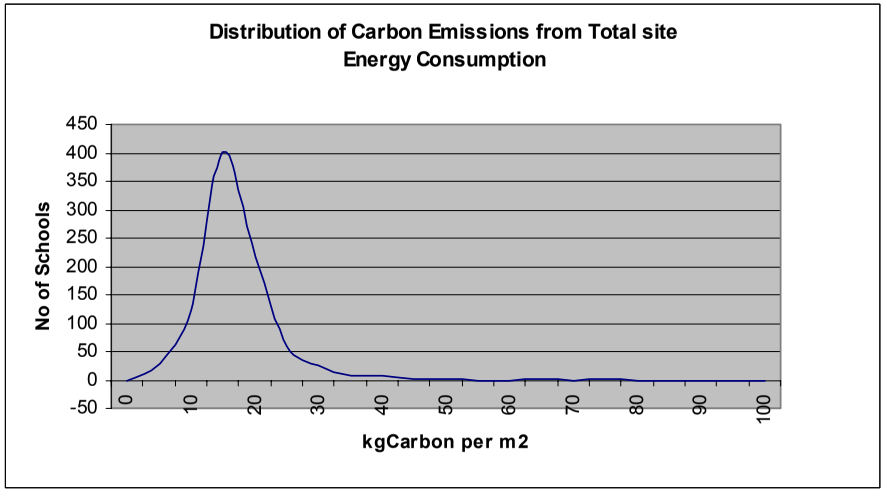


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.8	54.9	3.6	11.0	200.5	3.2	18.2	246.3	6.8
2nd Quartile	5.6	39.3	2.5	8.4	149.6	2.4	14.4	194.2	4.9
1st Quartile	4.0	27.9	1.8	5.9	106.1	1.7	11.2	148.1	3.5

Sample data	
Total Schools	**2084**
Total floor area m^2	**2,742,182**
Average floor area m^2	**1,316**

Primary School (no pool) – built 1919-1939



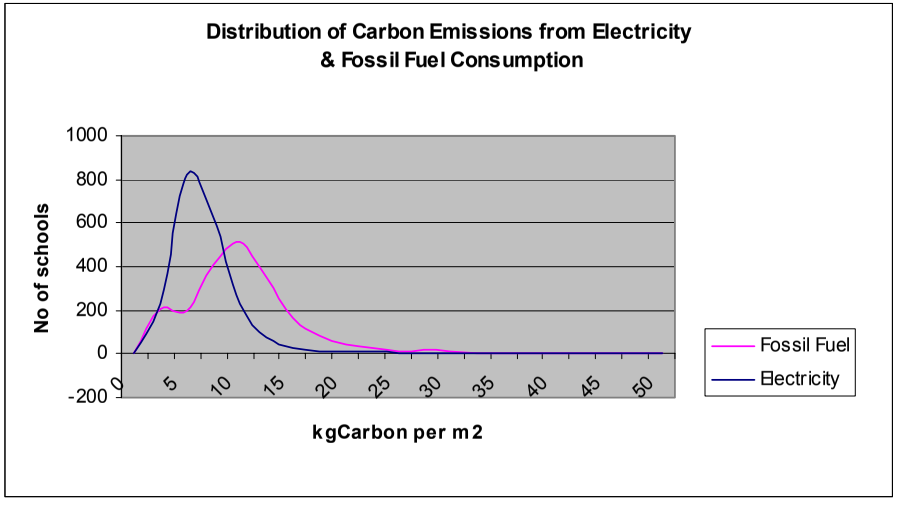


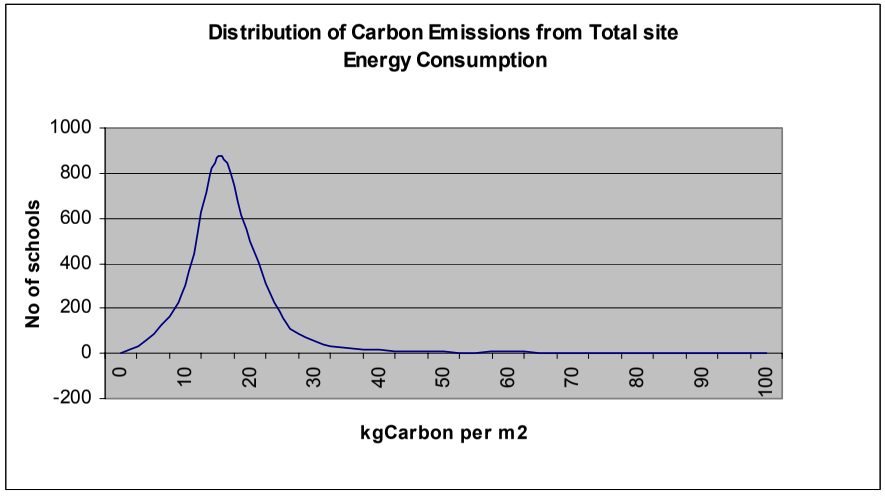
Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.0	42.5	2.8	11.4	209.9	3.4	16.8	247.1	6.1
2nd Quartile	4.4	30.9	2.0	8.8	161.4	2.6	13.6	195.2	4.6
1st Quartile	3.1	22.0	1.4	6.8	123.8	2.0	10.9	157.1	3.4

Sample data

Total Schools	**881**
Total floor area m^2	**1,656,541**
Average floor area m^2	**1,880**

Primary School (no pool) – built 1946-1966



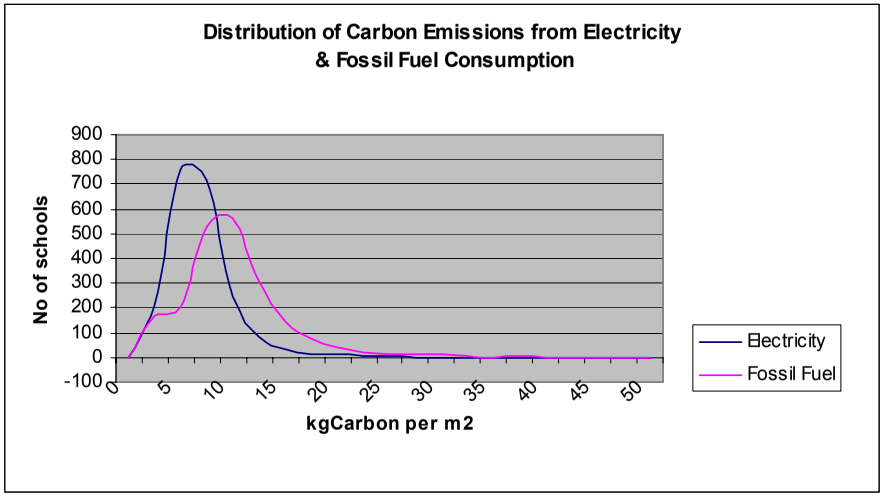


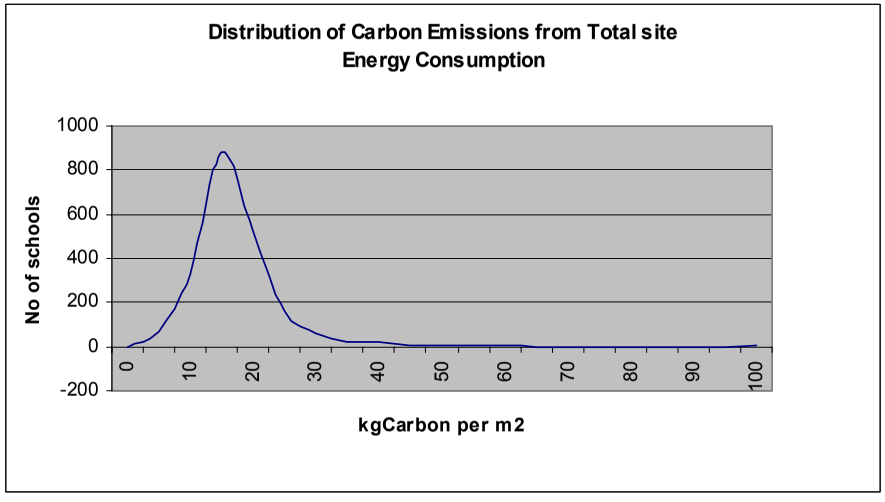
Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m/yr 2	kWh/m2	£/m2
3rd Quartile	6.7	47.4	3.1	11.5	205.9	3.3	17.2	242.6	6.4
2nd Quartile	5.0	34.9	2.3	8.5	157.6	2.5	13.7	193.0	4.8
1st Quartile	3.5	24.9	1.6	5.8	106.9	1.7	10.9	144.4	3.3

Sample data

Total Schools	**2060**
Total floor area m^2	**3,485,627**
Average floor area m^2	**1,692**

Primary School (no pool) – built 1967-1976



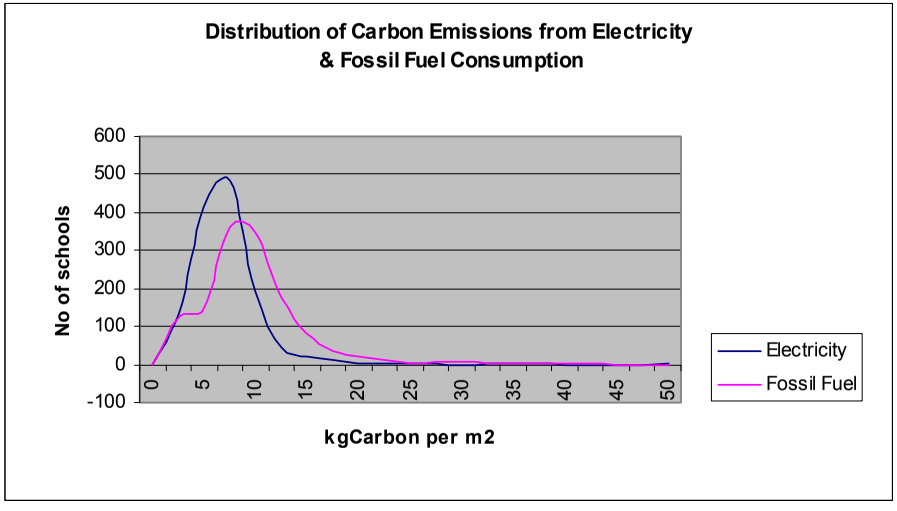


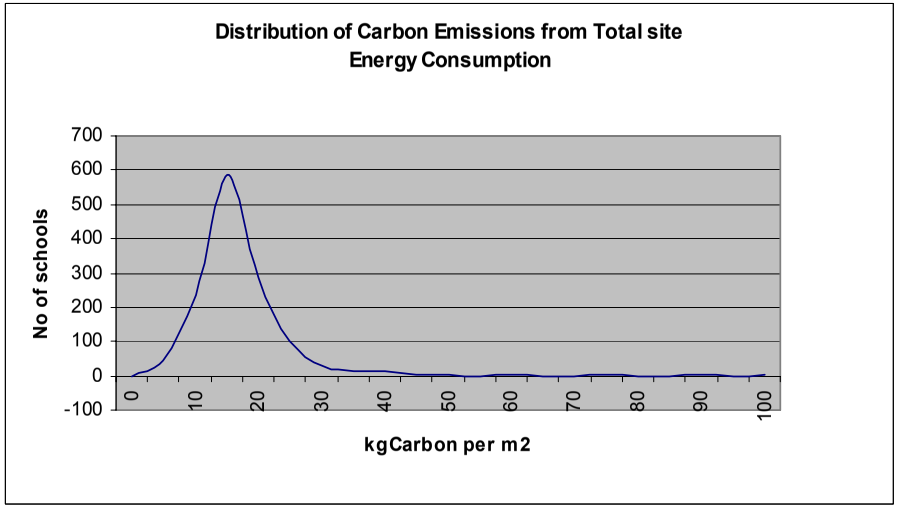
Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.0	49.4	3.2	10.8	196.3	3.1	17.2	240.0	6.3
2nd Quartile	5.2	36.9	2.4	8.1	150.6	2.4	13.8	190.1	4.8
1st Quartile	3.8	26.8	1.7	5.9	109.4	1.8	10.9	148.0	3.5

Sample data

Total Schools	**2107**
Total floor area m^2	**3,094,531**
Average floor area m^2	**1,469**

Primary School (no pool) – built 1976 onwards

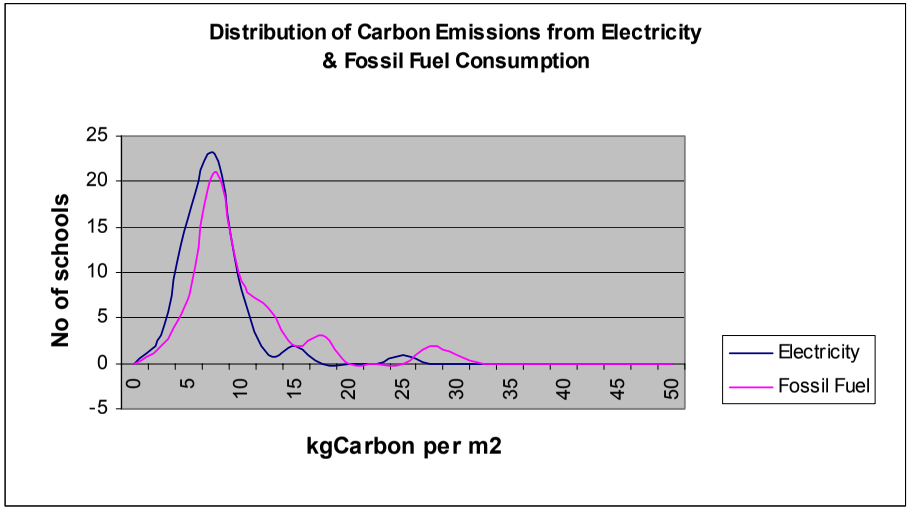


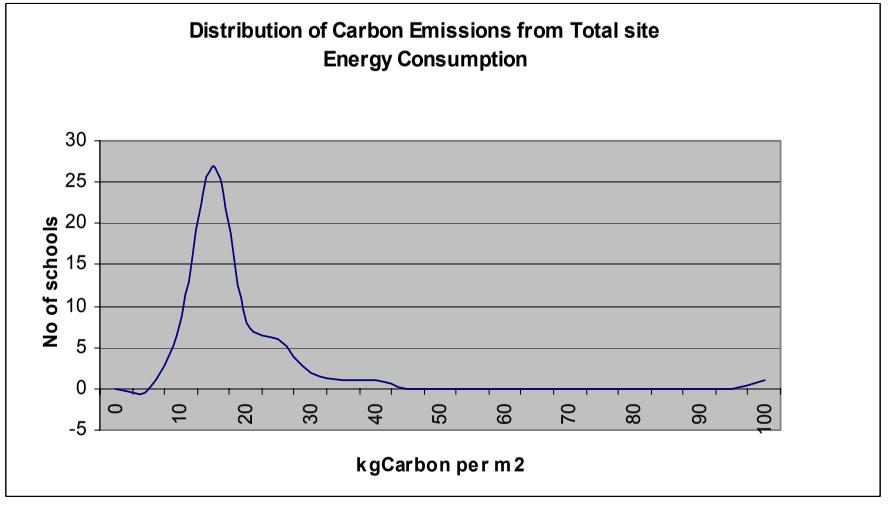


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.1	50.4	3.3	10.2	188.7	3.0	16.4	230.0	6.3
2nd Quartile	5.5	38.5	2.5	7.7	144.0	2.3	13.4	185.8	4.8
1st Quartile	3.9	27.6	1.8	5.6	104.9	1.7	10.5	144.7	3.5

Sample data	
Total Schools	**1331**
Total floor area m^2	**1,981,306**
Average floor area m^2	**1,489**

Primary School (no pool) – built 1995 onwards

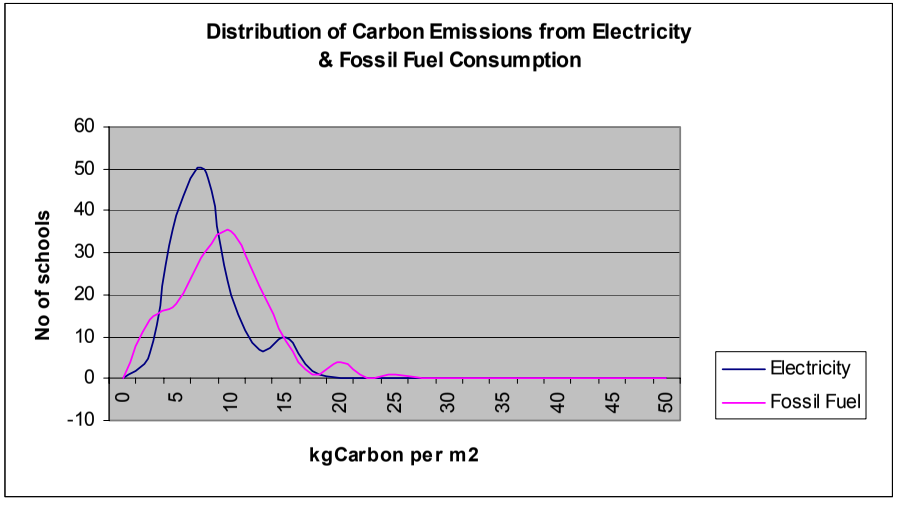


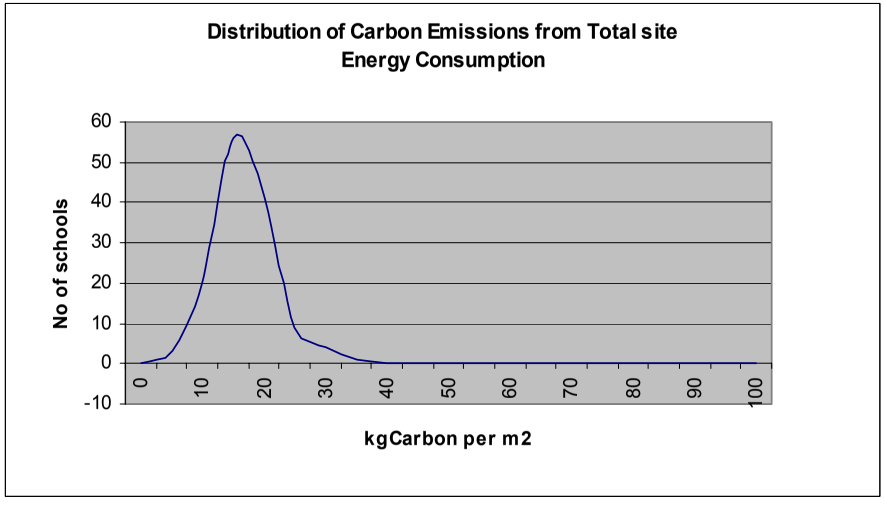


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.1	50.3	3.3	10.9	189.9	3.0	18.4	239.3	6.3
2nd Quartile	6.2	43.8	2.8	6.6	127.9	2.0	13.4	174.1	4.9
1st Quartile	4.5	31.7	2.1	5.5	105.2	1.7	11.0	146.7	3.7

Sample data	
Total Schools	**54**
Total floor area m²	**102,217**
Average floor area m²	**1,893**

Primary School (with pool) – built pre 1919

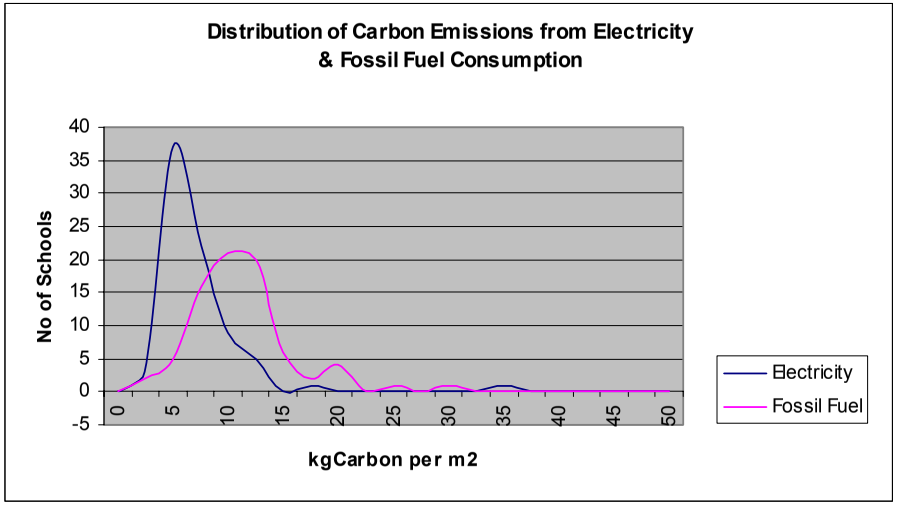


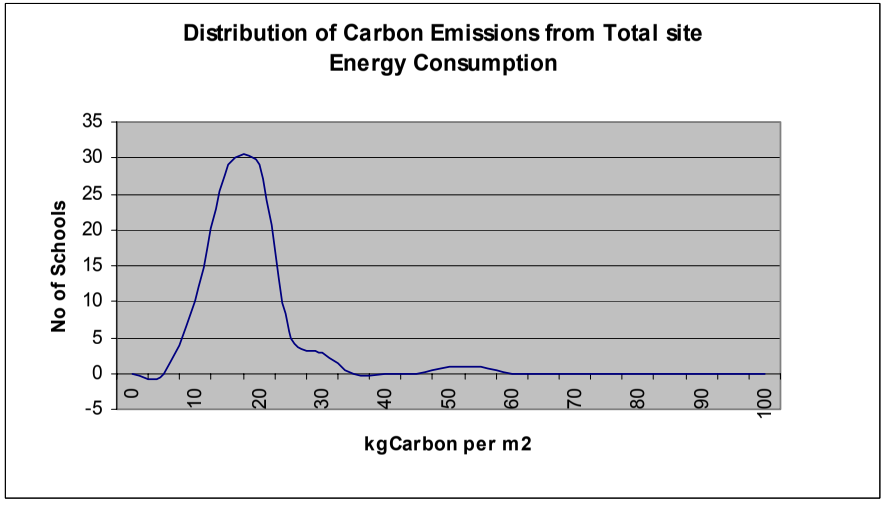


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.9	55.5	3.6	10.8	180.4	2.9	17.8	247.4	6.5
2nd Quartile	6.1	43.1	2.8	7.8	132.0	2.1	14.4	175.8	4.9
1st Quartile	4.7	32.8	2.1	5.3	89.7	1.4	11.3	140.3	3.6

Sample data	
Total Schools	**135**
Total floor area m^2	**169,718**
Average floor area m^2	**1,257**

Primary School (with pool) – built 1919-1939

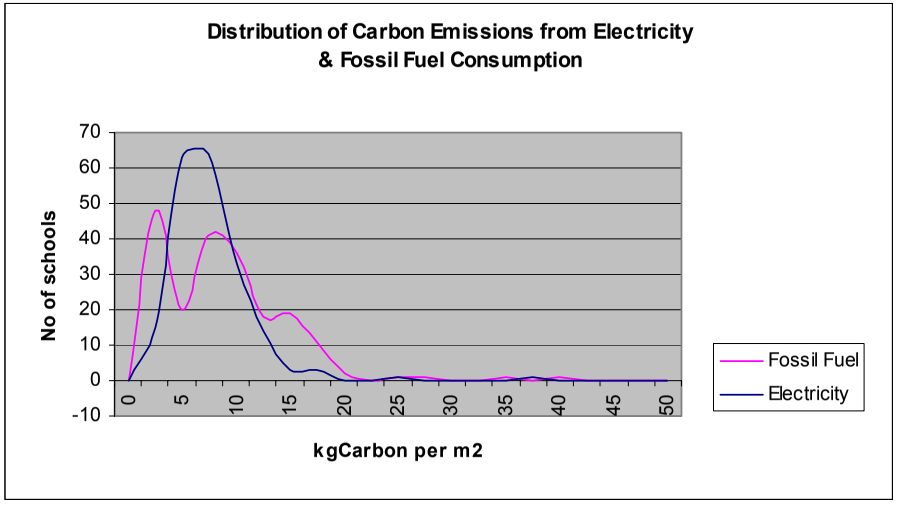


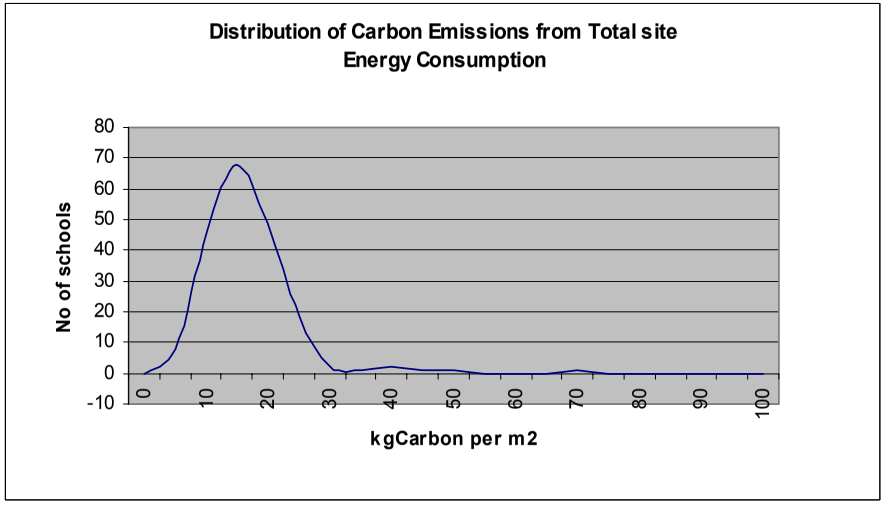


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.9	48.8	3.2	11.7	219.8	3.5	18.4	261.1	6.7
2nd Quartile	5.0	35.1	2.3	9.4	172.8	2.8	14.9	213.8	5.0
1st Quartile	3.6	25.5	1.7	7.2	124.4	2.0	11.4	159.0	3.6

Sample data	
Total Schools	**78**
Total floor area m²	**159,654**
Average floor area m²	**2,047**

Primary School (with pool) – built 1946-1966

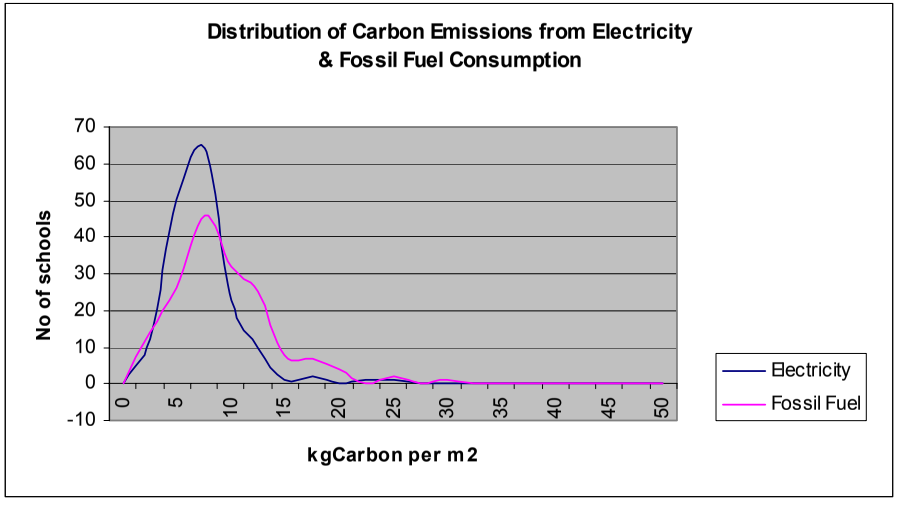


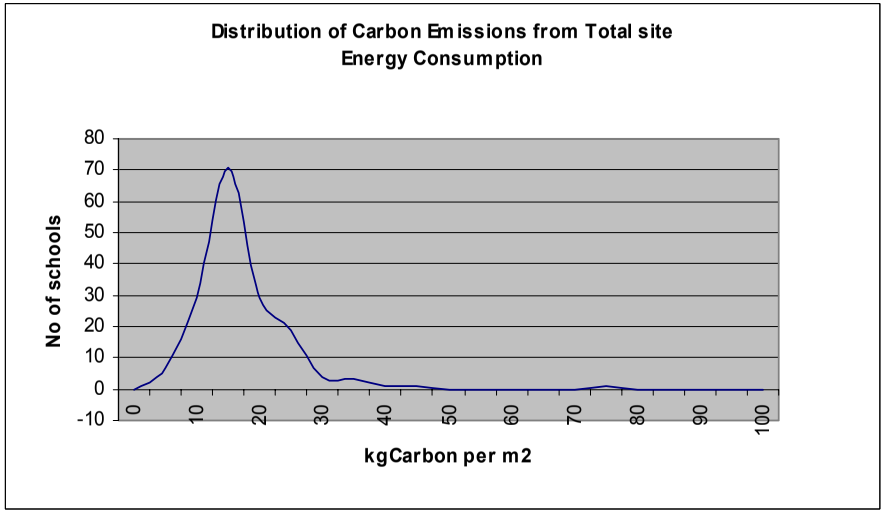


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	8.2	58.1	3.8	11.1	187.5	3.0	17.8	245.1	6.8
2nd Quartile	5.9	41.3	2.7	7.0	124.1	2.0	13.2	171.0	4.7
1st Quartile	4.1	29.0	1.9	2.7	49.6	0.8	9.8	105.4	2.7

Sample data	
Total Schools	**199**
Total floor area m^2	**353,330**
Average floor area m^2	**1,776**

Primary School (with pool) – built 1967-1976

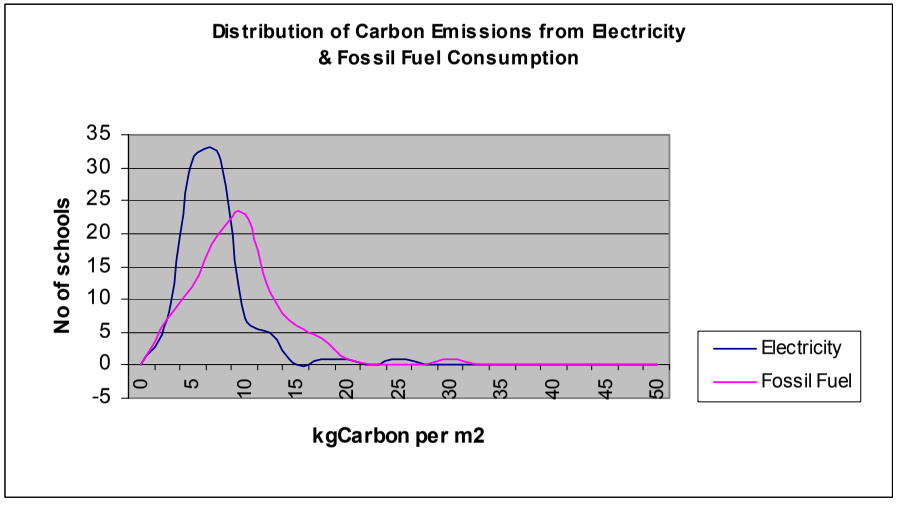


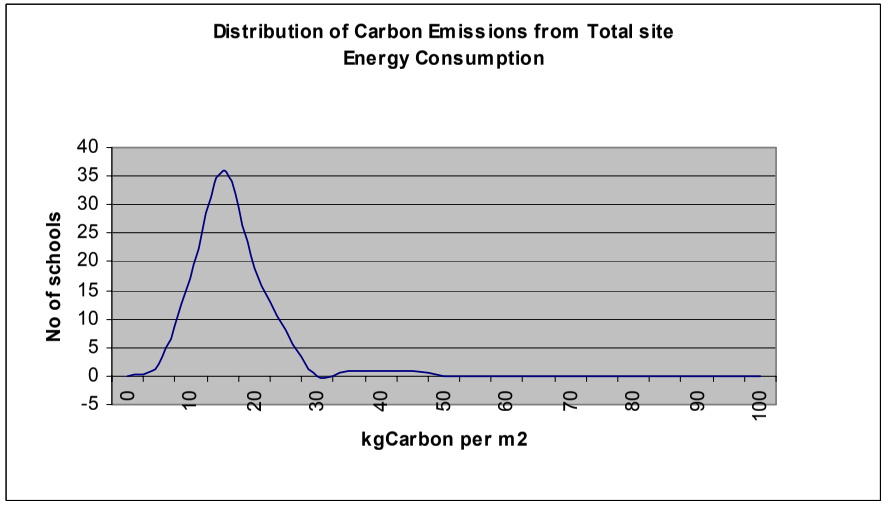


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.3	51.7	3.4	10.5	187.9	3.0	16.9	232.0	6.4
2nd Quartile	5.8	41.0	2.7	7.3	133.9	2.1	13.1	177.3	4.8
1st Quartile	4.1	29.1	1.9	5.1	91.0	1.5	10.5	132.6	3.3

Sample data	
Total Schools	**165**
Total floor area m²	**258,856**
Average floor area m²	**1,569**

Primary School (with pool) – built 1976 onwards

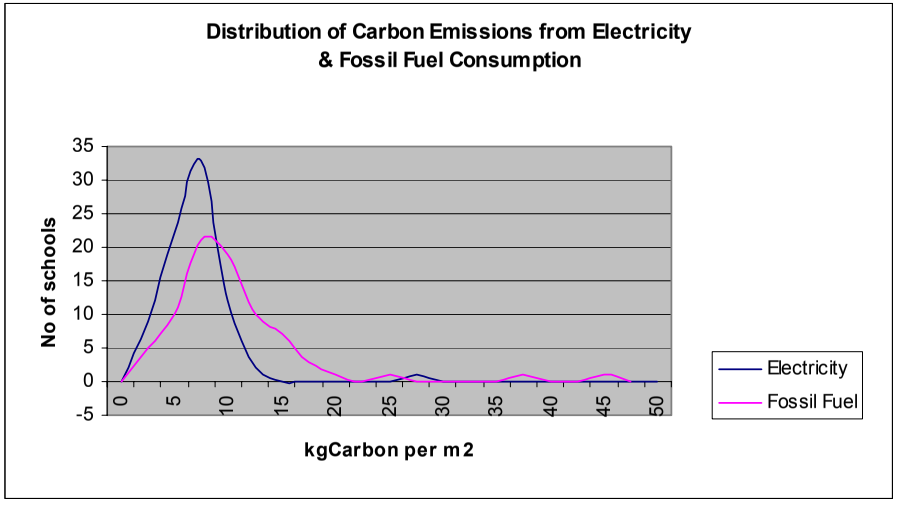


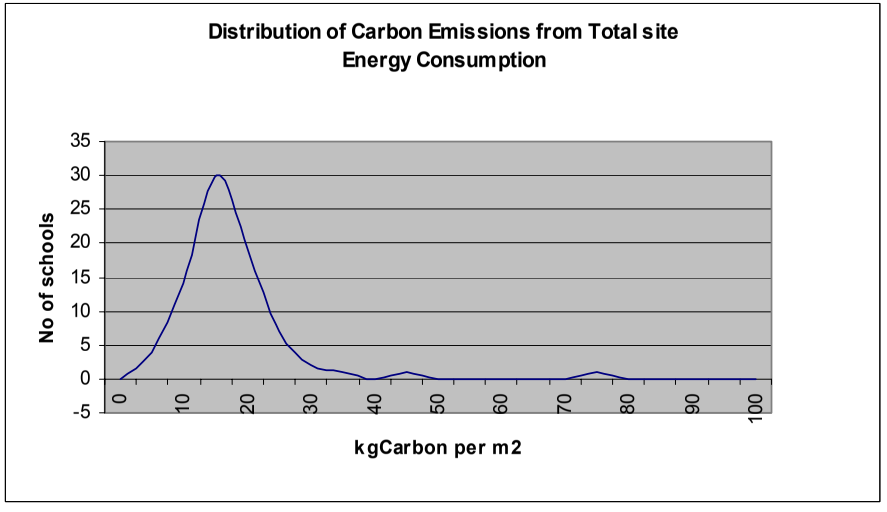


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.2	50.4	3.3	10.2	193.3	3.1	16.8	231.2	6.4
2nd Quartile	5.5	38.7	2.5	8.0	144.1	2.3	12.9	186.5	4.8
1st Quartile	3.8	27.0	1.7	5.5	105.1	1.7	11.1	135.4	3.4

Sample data	
Total Schools	**85**
Total floor area m^2	**134,762**
Average floor area m^2	**1,585**

Secondary School (no pool) – built pre 1919

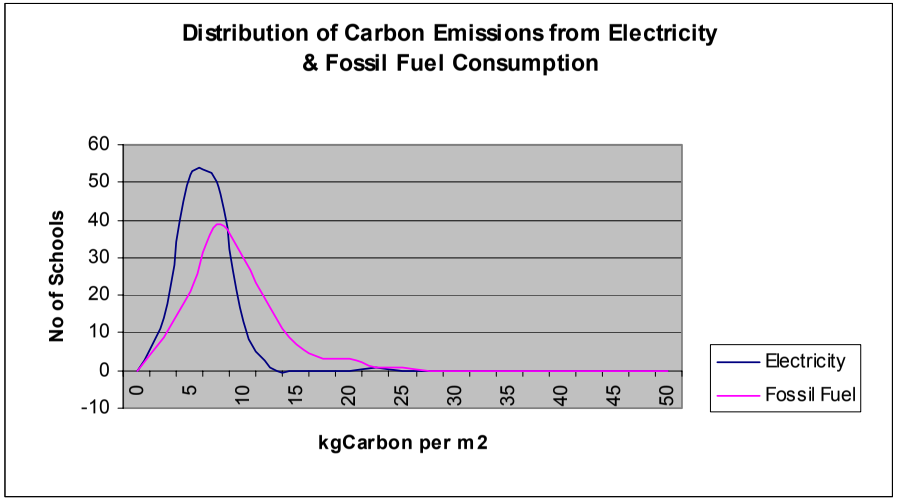


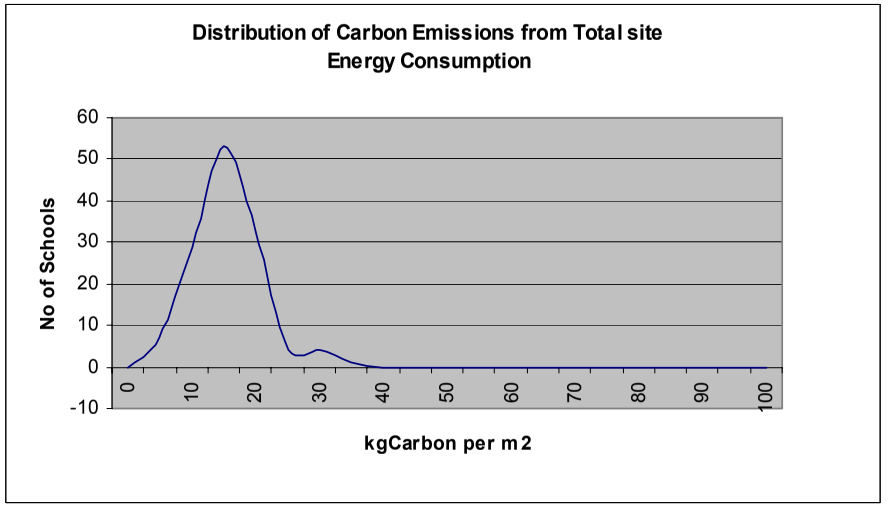


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.8	48.2	3.1	10.8	193.5	3.1	16.5	231.5	6.2
2nd Quartile	5.3	37.3	2.4	8.4	154.6	2.5	12.9	186.4	4.9
1st Quartile	4.0	28.0	1.8	5.7	108.3	1.7	10.3	140.9	3.5

Sample data	
Total Schools	79
Total floor area m^2	612,269
Average floor area m^2	7,750

Secondary School (no pool) – built 1919-1939

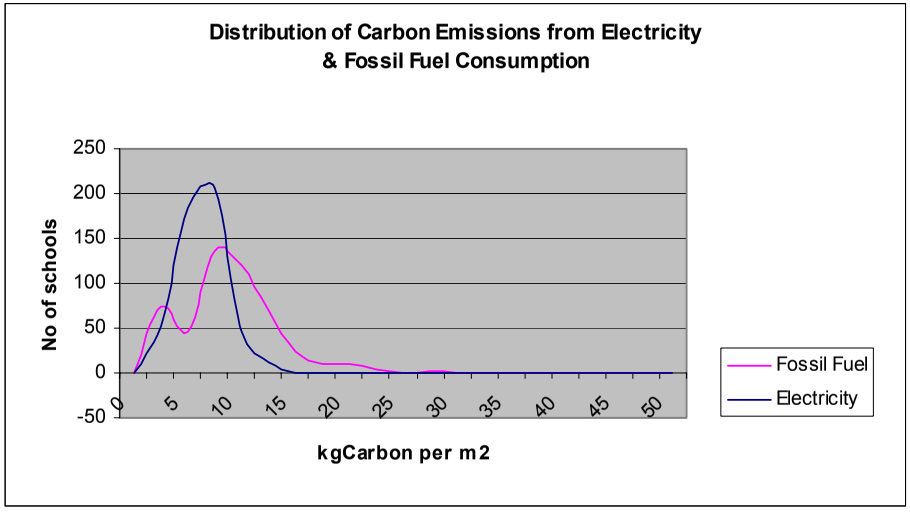


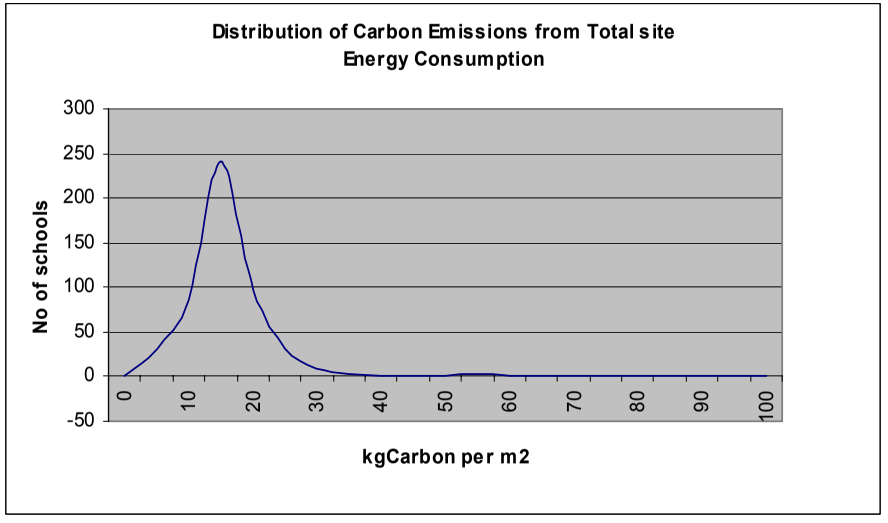


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.4	44.9	2.9	9.9	172.3	2.8	15.7	215.1	5.7
2nd Quartile	5.0	35.1	2.3	7.2	132.1	2.1	12.3	170.0	4.4
1st Quartile	3.9	27.5	1.8	5.4	99.4	1.6	9.5	132.3	3.4

Sample data	
Total Schools	**131**
Total floor area m^2	**1,078,530**
Average floor area m^2	**8,233**

Secondary School (no pool) – built 1946-1966

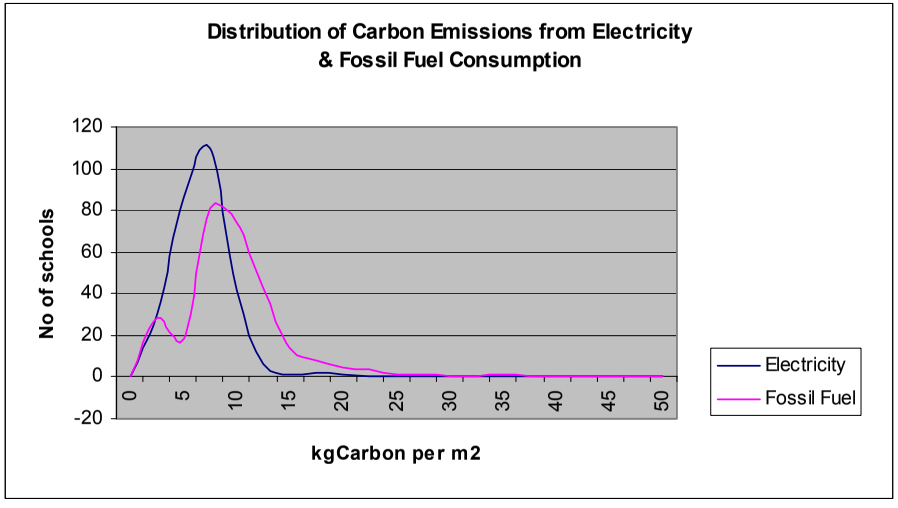


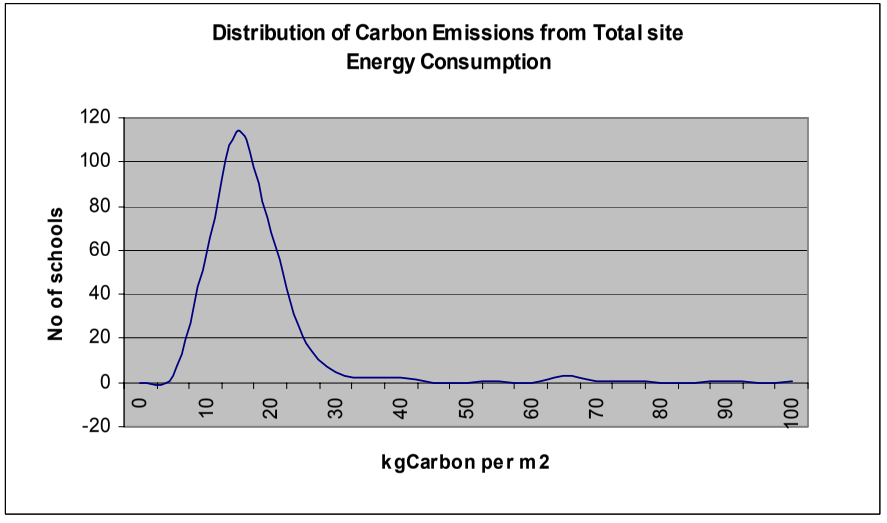


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.2	44.1	2.9	10.0	181.2	2.9	15.4	215.6	5.8
2nd Quartile	5.1	36.3	2.4	7.5	141.1	2.3	13.0	177.4	4.6
1st Quartile	4.1	29.0	1.9	5.1	100.0	1.6	10.2	129.0	3.5

Sample data	
Total Schools	**508**
Total floor area m²	**4,337,103**
Average floor area m²	**8,538**

Secondary School (no pool) – built 1967-1976

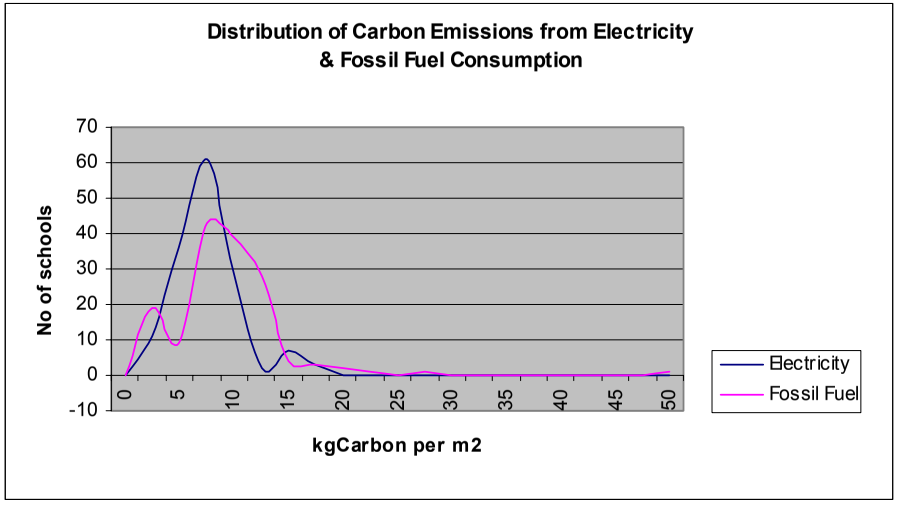


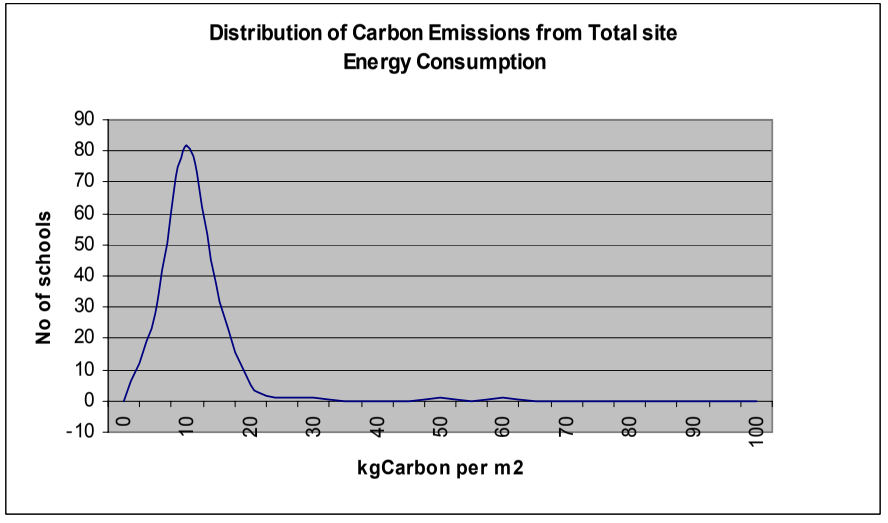


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.1	50.1	3.2	10.4	185.3	3.0	16.9	233.3	6.2
2nd Quartile	5.4	38.2	2.5	7.9	145.2	2.3	13.2	183.3	4.8
1st Quartile	3.8	26.8	1.7	5.9	109.3	1.7	10.4	141.0	3.5

Sample data	
Total Schools	**282**
Total floor area m^2	**2,161,306**
Average floor area m^2	**7,664**

Secondary School (no pool) – built 1976 onwards

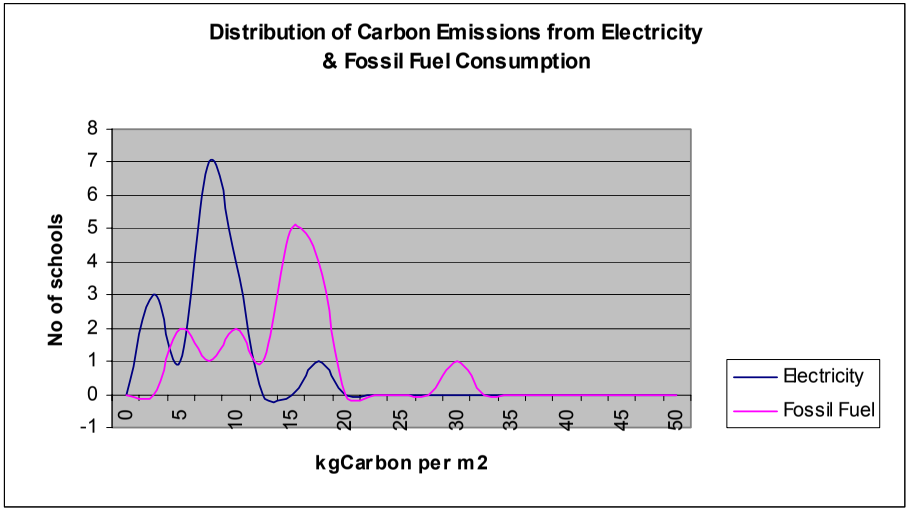


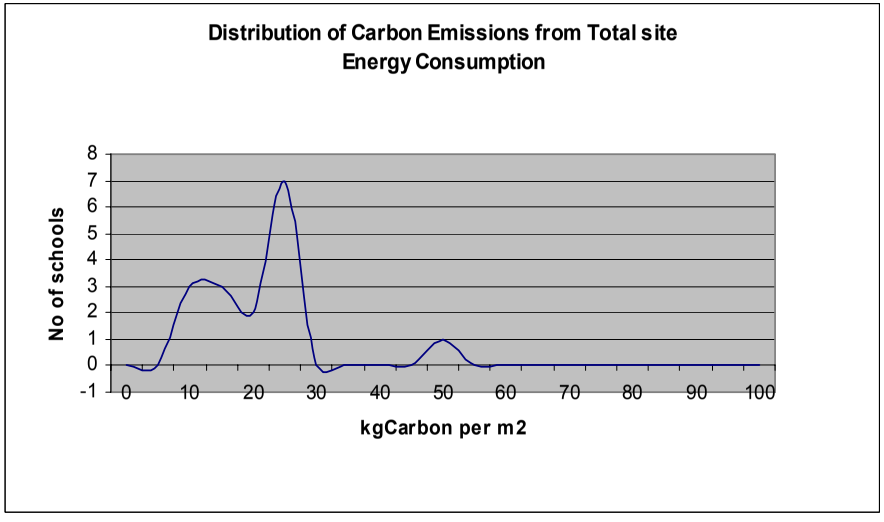


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.9	56.0	3.6	10.4	190.8	3.1	17.7	243.8	6.7
2nd Quartile	6.0	42.1	2.7	7.9	143.5	2.3	14.1	190.4	5.0
1st Quartile	4.6	32.5	2.1	5.8	111.9	1.8	11.0	151.1	3.9

Sample data	
Total Schools	**152**
Total floor area m²	**1,308,220**
Average floor area m²	**8,607**

Secondary School (with pool) – built pre 1919

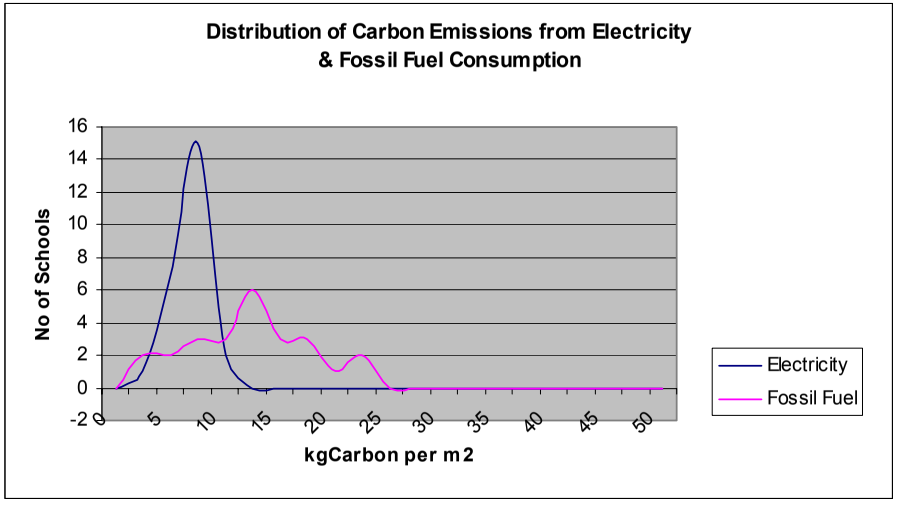


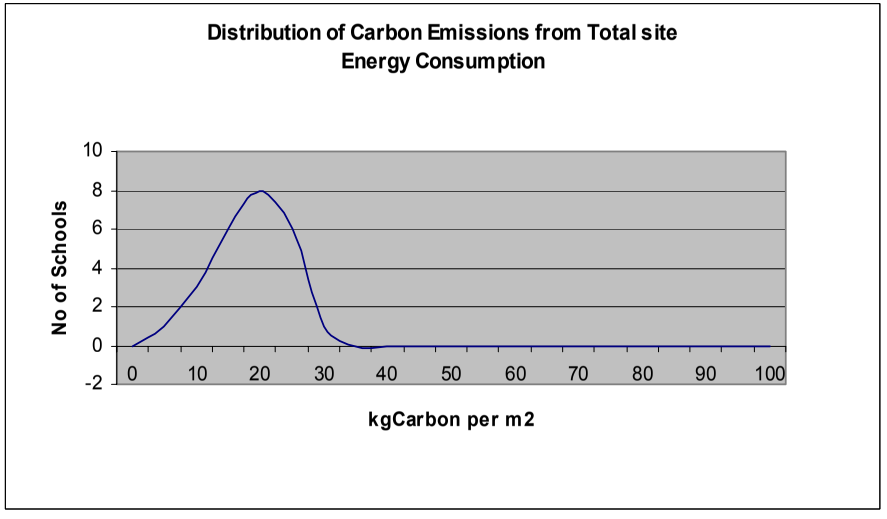


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.8	55.0	3.6	15.3	292.3	4.7	22.8	342.4	8.2
2nd Quartile	6.9	48.4	3.1	13.5	248.9	4.0	20.4	282.8	7.1
1st Quartile	5.0	35.3	2.3	8.5	165.0	2.6	13.4	197.6	4.9

Sample data	
Total Schools	**16**
Total floor area m²	**136,859**
Average floor area m²	**8,554**

Secondary School (with pool) – built 1919-1939

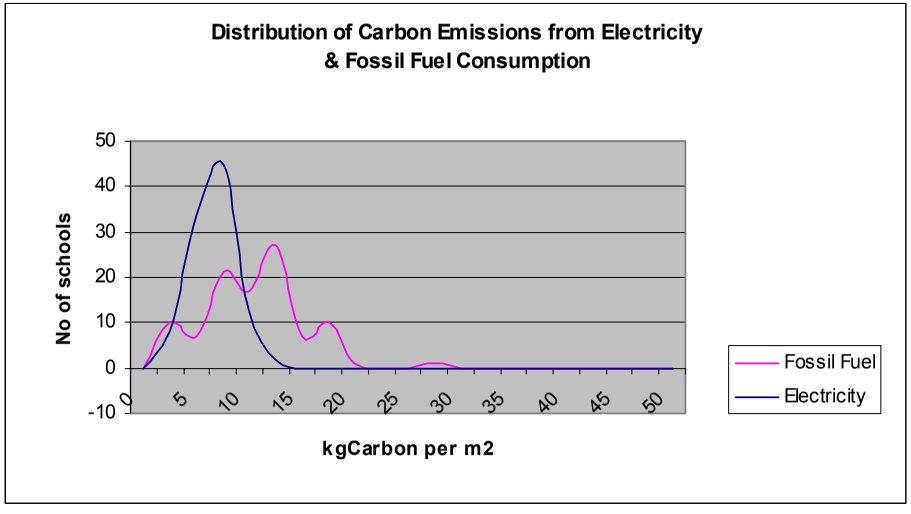


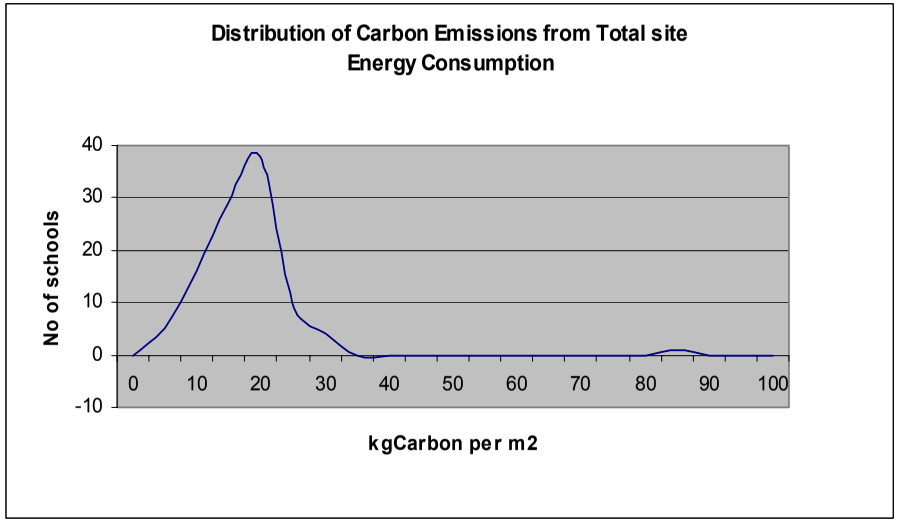


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.8	47.8	3.1	14.6	273.4	4.4	20.7	314.4	7.5
2nd Quartile	5.5	38.8	2.5	10.4	193.3	3.1	16.2	222.7	5.6
1st Quartile	4.5	32.0	2.1	7.4	127.8	2.0	14.2	165.5	4.1

Sample data	
Total Schools	**25**
Total floor area m²	**216,662**
Average floor area m²	**8,666**

Secondary School (with pool) – built 1946-1966

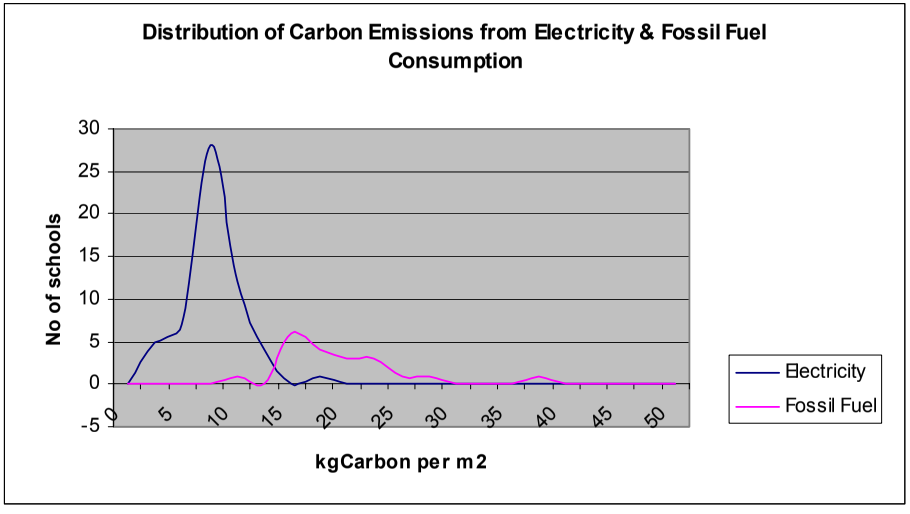


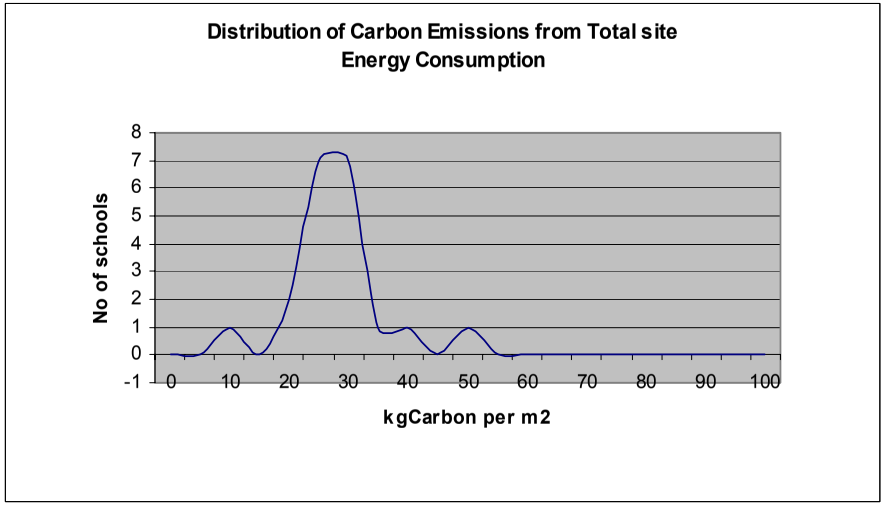


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	6.4	45.0	2.9	11.5	219.4	3.5	18.4	264.0	6.4
2nd Quartile	5.5	38.8	2.5	9.5	170.2	2.7	15.2	206.0	5.2
1st Quartile	4.5	31.5	2.0	6.0	104.9	1.7	10.9	142.1	3.7

Sample data	
Total Schools	**102**
Total floor area m^2	**863,599**
Average floor area m^2	**8,467**

Secondary School (with pool) – built 1967-1976

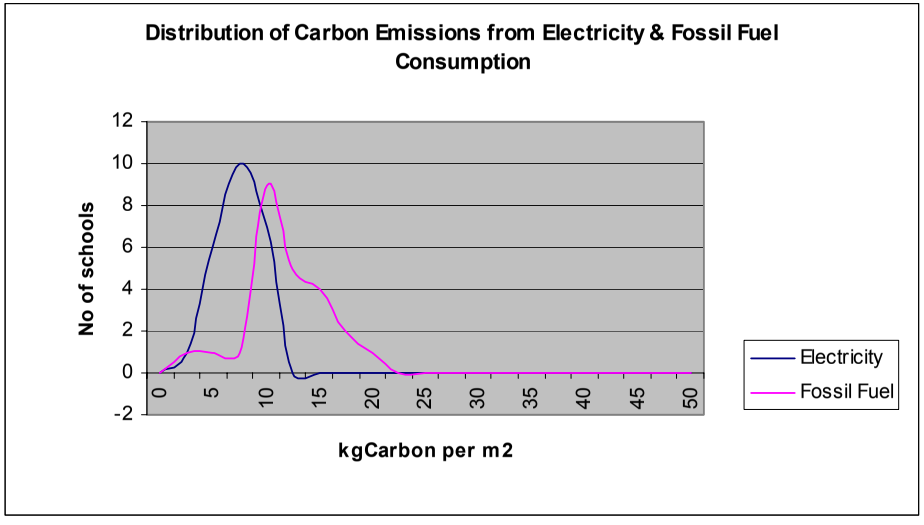


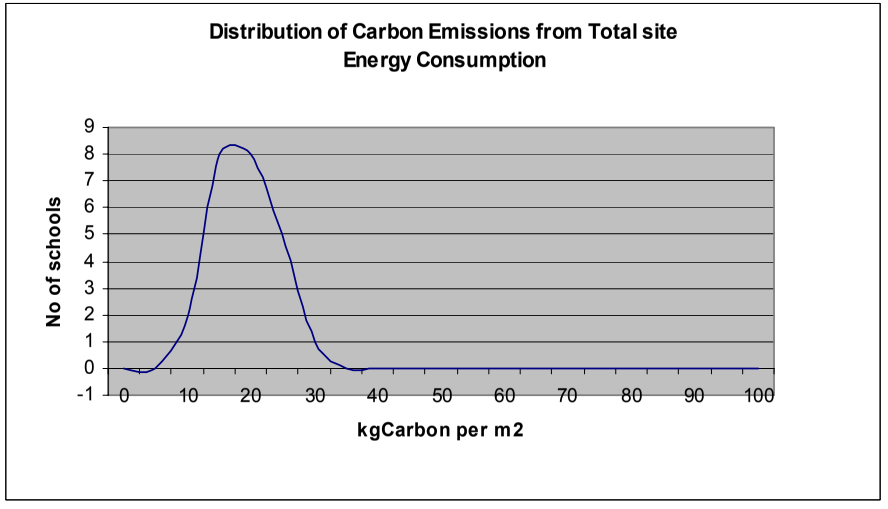


Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.7	54.6	3.5	14.6	274.6	4.4	23.0	308.0	7.9
2nd Quartile	6.4	44.9	2.9	10.2	190.6	3.0	16.8	232.8	6.0
1st Quartile	5.4	38.3	2.5	8.0	150.9	2.4	13.4	179.8	4.9

Sample data	
Total Schools	**57**
Total floor area m²	**559,443**
Average floor area m²	**9,815**

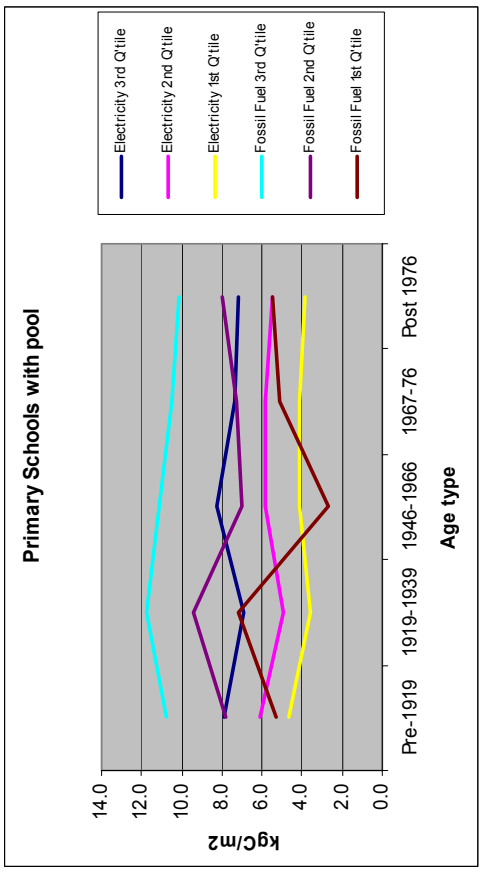
Secondary School (with pool) – built 1976 onwards

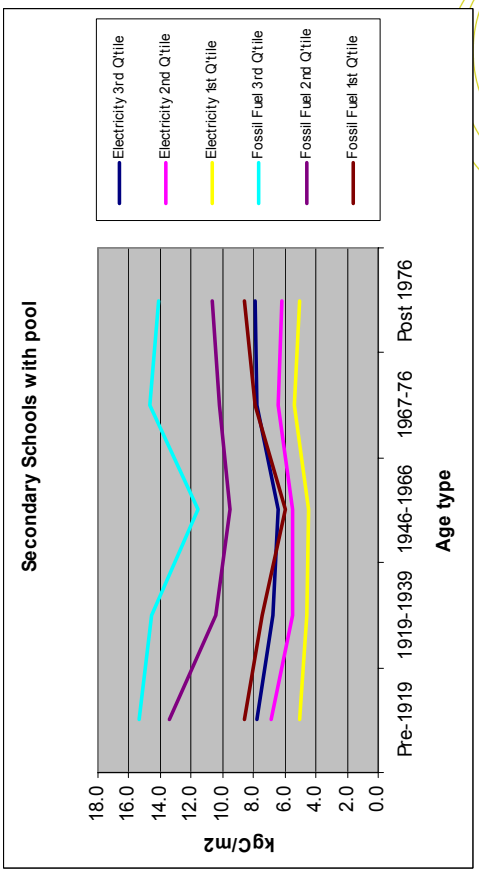


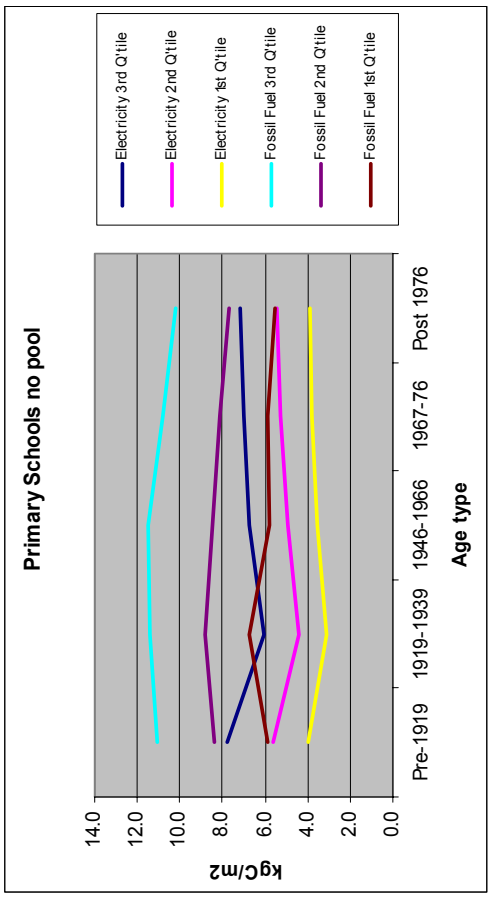


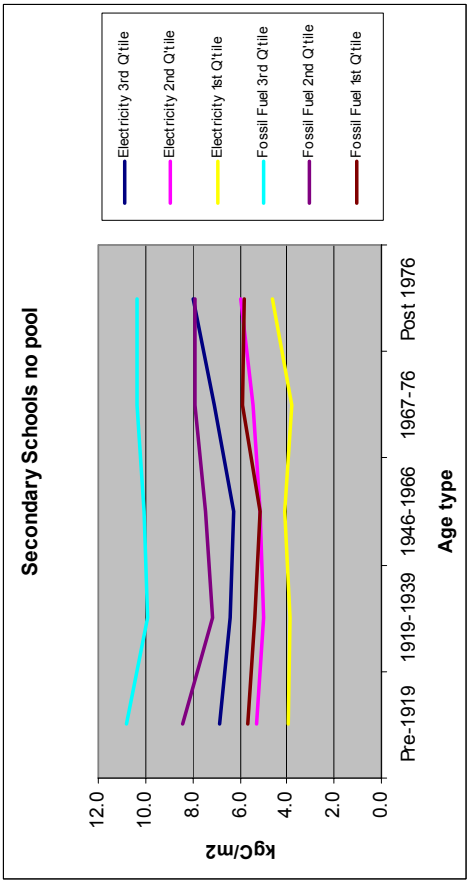
Quartiles	Electricity			Fossil Fuel			All Energy		
	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2	kgC/m2/yr	kWh/m2	£/m2
3rd Quartile	7.9	55.8	3.6	14.1	254.9	4.1	20.5	293.6	7.7
2nd Quartile	6.2	43.7	2.8	10.6	195.4	3.1	16.1	237.3	6.0
1st Quartile	5.0	35.2	2.3	8.6	162.4	2.6	14.1	196.7	4.9

Sample data	
Total Schools	**24**
Total floor area m^2	**213,999**
Average floor area m^2	**8,917**









Summary Data

Appendix 2 – Results of modelling the energy saving measures

New Build Primary School

Notional new build primary school - plus renewables (average floor area of existing estate 1544 m2)		Building Engineering Rating kgC/m^2	The effect of carbon saving measures									BREEAM assessment				
			Carbon saving kgC/m^2	Cost Saving £/m^2	Installed cost £/m^2 floor area	% Replication Potential - see notes	Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Target Emissions Rating kgC/m^2	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
	Base School Evaluation	**8.52**										8.67	pass	1.73%	**1**	**Good**
Improvement Measure																
Renewables	biomass boiler (160 kWt)	**3.14**	**5.39**	**0.92**	**21.08**	**10**	**3759**	**1.28**	**15**	**23**	**11**	8.67	pass	63.81%	**14**	**Very Good**
	solar thermal (12m^2 collector area)	**8.35**	**0.17**	**0.12**	**6.25**	**10**	**119**	**0.17**	**4**	**52**	**26**	8.67	pass	3.74%	**2**	**Good**
	PVs (10m^2 collector area)	**8.41**	**0.11**	**0.06**	**3.75**	**10**	**77**	**0.08**	**3**	**63**	**31**	8.67	pass	3.02%	**2**	**Good**
	wind turbine (6kWe)	**7.64**	**0.88**	**0.47**	**14.28**	**10**	**612**	**0.66**	**10**	**30**	**15**	8.67	pass	11.92%	**6**	**Very Good**
	ground source heat pumps	**5.91**	**2.61**	**0.08**	**44.43**	**10**	**1822**	**0.11**	**31**	**See cost notes**		8.67	pass	31.86%	**11**	**Very Good**

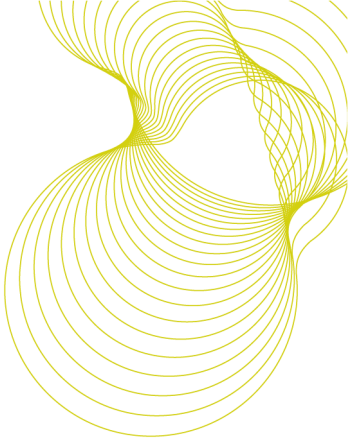
Notes to replication potential assumptions

Renewables - A take-up rate of 10% of the total school building stock to be rebuilt (i.e. 25% of the overall total) has been assumed. The total floor area of the estate is equal to 56.3 million m^2 made up of 27.9 million m^2 primary (used in this example) and 28.4 milion m^2 secondary .

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 to Q4 2005.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).

Cost notes

Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate.
The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.



Notional primary school - Refurbishment (average floor area of existing estate 1544m^2)		Building Emissions Rating kgC/m^2/yr	Carbon Improvement Measures: Carbon saving kgC/m^2/yr	Energy Cost Saving £/m^2	Installed cost £/m^2 floor area	% Replication Potential - see notes	Overall Potential Savings tC	Overall potential cost saving £m	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	BREEAM Assessment: Target Emissions Rating kgC/m^2/yr	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
School evaluation post major refurbishment		**9.35**														
Renewables	biomass boiler (160 kWt)	**3.97**	**5.39**	**0.92**	**21.08**	**10**	**3759**	**0.90**	**14.72**	**22.9**	**11.5**	8.7	pass	54%	**13**	**Very Good**
	solar thermal (12m2 collector area)	**9.18**	**0.17**	**0.12**	**6.25**	**10**	**119**	**0.12**	**4.36**	**52.1**	**26.0**	8.7	pass	-6%	**0**	**Good**
	PVs (10m2 collector area)	**9.24**	**0.11**	**0.06**	**3.75**	**10**	**77**	**0.06**	**2.62**	**62.5**	**31.3**	8.7	pass	-7%	**0**	**Good**
	wind turbine (6kWe)	**8.47**	**0.88**	**0.47**	**14.28**	**10**	**612**	**0.46**	**9.97**	**30.4**	**15.2**	8.7	pass	2%	**2**	**good**
	ground source heat pumps	**6.74**	**2.61**	**0.08**	**44.43**	**10**	**1822**	**0.08**	**31.02**	**See cost notes**		8.7	pass	22%	**10**	**Very Good**
Potential savings in minor refurbishment (generally less than 5yrs. payback)		**13.43**														
Minor refurbishments	Lighting- replace T12 with T8 and/or compact fluorescesnt, average efficacy 65lumens per circuit watt.	**13.30**	**0.13**	**0.07**	**0.06**	**6**	**201**	**0.11**	**0.09**	**0.9**	**N/A**	N/A				
	Lighting controls – occupancy sensing to corridors and toilets (65lm/cct watt).	**12.95**	**0.48**	**0.26**	**0.53**	**10**	**1347**	**0.72**	**1.50**	**2.1**	**N/A**	N/A				
	Timeswitch control of office equipment, vending machines, computers, etc.	**13.26**	**0.17**	**0.09**	**0.03**	**3**	**142**	**0.08**	**0.02**	**0.3**	**N/A**	N/A				
	Introduce passive ventilation.	**13.29**	**0.14**	**0.06**	**0.24**	**10**	**393**	**0.16**	**0.68**	**4.2**	**N/A**	N/A				
	H&V controls improvements typically weather compensation, TRVs and optimum start and minor system upgrades.	**11.73**	**1.70**	**0.70**	**1.46**	**5**	**2421**	**1.00**	**2.08**	**2.1**	**N/A**	N/A				
	HWS controls and efficiency improvements.	**13.26**	**0.17**	**0.07**	**0.07**	**3**	**142**	**0.06**	**0.06**	**1.0**	**N/A**	N/A				
	Insulate boilerhouse pipework/fittings.	**13.28**	**0.15**	**0.06**	**0.12**	**11**	**465**	**0.19**	**0.36**	**1.9**	**N/A**	N/A				
	Draught proofing.	**13.09**	**0.34**	**0.14**	**0.09**	**3**	**242**	**0.10**	**0.06**	**0.6**	**N/A**	N/A				
	Controls for fridges, freezers & chilled appliances.	**13.30**	**0.13**	**0.07**	**0.11**	**2**	**71**	**0.04**	**0.06**	**1.6**	**N/A**	N/A				

Notes to replication potential assumptions

Major Refurb - the replication potential is assumed to be 25% of the total building stock in line with the major refurbishment objectives of the Building Schools for the Future programme.

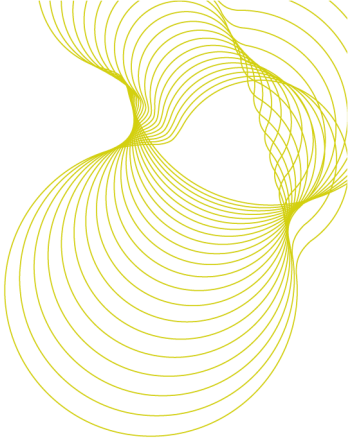
Minor Refurb - the replication potential is assumed to be the lower of 15% of the total building stock (i.e. those buildings the will not be rebuilt or undergo major refurbishment) and modified according to the replication potential identified from previous school surveys. In the case of the swimming pool improvements the formula is applied only to those schools with pools. As mentioned in the previous section savings are based on 77% of the potential suggested by the survey sample.

Renewables - A take-up rate of 10% of the total school building stock to be refurbished (25%) has been assumed. The total floor area of the estate is equal to 56.3 million m^2 made up of 27.9 million m^2 primary (used in this example) and 28.4 milion m^2 secondary .

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 to Q4 2005.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).

Cost notes

Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate.
The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.



Notional primary school - Refurbishment (average floor area of existing estate 1544m^2)		Building Emissions Rating kgC/m^2/yr	Carbon Improvement Measures: Carbon saving kgC/m^2/yr	Energy Cost Saving £/m^2	Installed cost £/m^2 floor area	% Replication Potential - see notes	Overall Potential Savings tC	Overall potential cost saving £m	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	BREEAM Assessment: Target Emissions Rating kgC/m^2/yr	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
Base School Evaluation		**13.43**														
Improvement Measure																
Major Refurbishment	1. Lighting – replace T12 with T5 throughout –average efficacy 100 lumens per circuit watt	**13.07**	**0.36**	**0.19**	**37.51**	**25**	**880**	**1.34**	**261.85**	**195.8**	**97.9**	8.7	fail	-51%	0	**Good**
	2. Lighting controls – dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**13.04**	**0.39**	**0.21**	**0.97**	**25**	**2723**	**1.45**	**6.77**	**4.7**	**2.3**	8.7	fail	-50%	0	**Good**
	3. Lighting controls – occupancy sensing to corridors and toilets plus dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**12.93**	**0.50**	**0.27**	**1.41**	**25**	**3490**	**1.86**	**9.84**	**5.3**	**2.6**	8.7	fail	-49%	0	**Good**
	4. Upgrade heating – replace pre ECA standard boilers with post ECA standard	**10.42**	**3.01**	**1.24**	**4.83**	**25**	**21012**	**8.68**	**33.72**	**3.9**	**1.9**	8.7	fail	-20%	0	**Good**
	5. Single glazing replaced by 2005 specification double glazing (also assumes draughtproofing improvement)	**12.56**	**0.87**	**0.36**	**31.93**	**25**	**6073**	**2.51**	**222.90**	**88.9**	**44.4**	8.7	fail	-45%	0	**Good**
	6. Roof insulation – flat, minimal insulation replaced with 2005 regs compliant	**10.75**	**2.68**	**1.11**	**68.00**	**25**	**18709**	**7.73**	**474.70**	**61.4**	**30.7**	8.7	fail	-24%	0	**Good**
	7. Cavity wall insulation, blown balls, full fill	**12.63**	**0.80**	**0.33**	**3.17**	**25**	**5585**	**2.31**	**22.13**	**9.6**	**4.8**	8.7	fail	-46%	0	**Good**
	8. Post war - cavity wall insulation added, boiler and heating upgraded, lighting T5 and controls, double glazing.	**9.25**	**4.18**	**1.80**	**68.92**	**23**	**26554**	**11.44**	**437.82**	**38.3**	**19.1**	8.7	fail	-7%	0	**Good**
	9 As 8 plus new flat roof and insulation	**5.33**	**8.10**	**3.49**	**146.85**	**23**	**52021**	**22.41**	**943.12**	**42.1**	**21.0**	8.7	pass	39%	11	**Very Good**
	10 Pre- war (1945) Boiler and htg upgraded, lighting T5 and controls and double glazing.	**9.35**	**4.08**	**1.76**	**74.68**	**12**	**13956**	**6.01**	**255.45**	**42.5**	**21.2**	8.7	fail	-8%	0	**Good**
	11 As 10 plus pitched roof insulation increased to 250mm	**7.60**	**5.83**	**2.51**	**92.68**	**12**	**19535**	**8.42**	**310.55**	**36.9**	**18.4**	8.7	pass	13%	7	**Very Good**

Notes to replication potential assumptions

Major Refurb - the replication potential is assumed to be 25% of the total building stock in line with the major refurbishment objectives of the Building Schools for the Future programme.

Minor Refurb - the replication potential is assumed to be the lower of 15% of the total building stock (i.e. those buildings the will not be rebuilt or undergo major refurbishment) and modified according to the replication potential identified from previous school surveys. In the case of the swimming pool improvements the formula is applied only to those schools with pools. As mentioned in the previous section savings are based on 77% of the potential suggested by the survey sample.

Renewables - A take-up rate of 10% of the total school building stock to be refurbished (25%) has been assumed. The total floor area of the estate is equal to 56.3 million m^2 made up of 27.9 million m^2 primary (used in this example) and 28.4 milion m^2 secondary .

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 to Q4 2005.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).
Cost notes		Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate. The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.

New Build Secondary School

Notional new build secondary school - plus renewables (average floor area of existing estate 8574m²)		Building Emissions Rating kgC/m²/yr	The effect of carbon saving measures									BREEAM assessment				
			Carbon saving kgC/m²/yr	Cost Saving £/m²	Installed cost £/m² floor area	% Replication Potential - see notes	Overall Potential Carbon Savings (tC)	Overall potential cost saving (£m)	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	Target Emissions Rating kgC/m²/yr	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
	Base Shool Evaluation	**9.22**										9.38	pass	1.63%	**1**	**Good**
Improvement Measure																
Renewables																
	biomass boiler (700kWt)	**3.84**	**5.39**	**0.92**	**11.56**	**10**	**7648**	**1.31**	**16.42**	**13**	**6**	9.38	pass	59.05%	**13**	**Very Good**
	solar thermal (66m² collector area)	**9.05**	**0.17**	**0.12**	**6.19**	**10**	**241**	**0.17**	**8.79**	**52**	**26**	9.38	pass	3.49%	**2**	**Good**
	PVs (55m² collector area)	**9.11**	**0.11**	**0.06**	**3.71**	**10**	**156**	**0.09**	**5.27**	**62**	**31**	9.38	pass	2.85%	**2**	**Good**
	wind turbine (25kWe)	**8.55**	**0.67**	**0.28**	**7.00**	**10**	**947**	**0.39**	**9.94**	**25**	**13**	9.38	pass	8.81%	**5**	**Very Good**
	ground source heat pumps	**6.61**	**2.61**	**0.08**	**44.43**	**10**	**3707**	**0.11**	**63.10**	**e cost notes**		9.38	pass	29.52%	**10**	**Very Good**

Notes to replication potential assumptions

Renewables - A take-up rate of 10% of the total school building stock that is to be rebuilt (i.e. 50% of the overall total) has been assumed. The total floor area of the estate is equal to 56.3 million m² made up of 27.9 million m² primary and 28.4 milion m² secondary (as used in this example).

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 - Q4 2550.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).

Cost notes

Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate.
The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.

Refurbishment of Secondary School

Notional secondary school - Refurbishment (average floor area of existing estate 8574m²)		Building Emissions Rating kgC/m²/yr	Carbon Improvement Measures: Carbon saving kgC/m²/yr	Energy Cost Saving £/m²	Installed cost £/m² floor area	% Replication Potential - see notes	Overall Potential Savings tC	Overall potential cost saving £m	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	BREEAM Assessment: Target Emissions Rating kgC/m²/yr	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
School evaluation post major refurbishment		**9.33**														
Renewables	biomass boiler (700kWt)	**3.95**	**5.39**	**0.92**	**11.56**	**10**	**5353**	**0.91**	**11.49**	**13**	**6**	9.38	pass	58.00%	**13**	**Very Good**
	solar thermal (66m2 collector area)	**9.16**	**0.17**	**0.12**	**6.19**	**10**	**169**	**0.12**	**6.15**	**52**	**26**	9.38	pass	2.00%	**2**	**Good**
	PVs (55m2 collector area)	**9.22**	**0.11**	**0.06**	**3.71**	**10**	**109**	**0.06**	**3.69**	**62**	**31**	9.38	pass	2.00%	**2**	**Good**
	wind turbine (25kWe)	**8.66**	**0.67**	**0.28**	**7.00**	**10**	**663**	**0.27**	**6.96**	**25**	**13**	9.38	pass	8.00%	**5**	**Very Good**
	ground source heat pumps	**6.72**	**2.61**	**0.08**	**44.43**	**10**	**2595**	**0.08**	**44.17**	**See cost notes**		9.38	pass	28.00%	**10**	**Very Good**
Potential savings in minor refurbishment (less than 5yrs. payback)		**13.43**														
Minor refurbishments	Lighting- replace T12 with T8 and/or compact fluorescesnt, average efficacy 65lumens per circuit watt.	**13.30**	**0.13**	**0.07**	**0.06**	**6**	**205**	**0.11**	**0.09**	**0.9**	**N/A**	N/A				
	Lighting controls – occupancy sensing to corridors and toilets (65lm/cct watt)	**12.95**	**0.48**	**0.26**	**0.53**	**10**	**1370**	**0.73**	**1.53**	**2.1**	**N/A**	N/A				
	Timeswitch control of office equipment, vending machines, computers, etc.	**13.26**	**0.17**	**0.09**	**0.03**	**3**	**145**	**0.08**	**0.02**	**0.3**	**N/A**	N/A				
	Introduce passive ventilation.	**13.29**	**0.14**	**0.06**	**0.24**	**10**	**400**	**0.17**	**0.69**	**4.2**	**N/A**	N/A				
	H&V controls improvements typically weather compensation, TRVs and optimum start and minor system upgrades.	**11.73**	**1.70**	**0.70**	**1.46**	**5**	**2463**	**1.02**	**2.12**	**2.1**	**N/A**	N/A				
	HWS controls and efficiency improvements.	**13.26**	**0.17**	**0.07**	**0.07**	**3**	**145**	**0.06**	**0.06**	**1.0**	**N/A**	N/A				
	Insulate boilerhouse pipework/fittings.	**13.28**	**0.15**	**0.06**	**0.12**	**11**	**473**	**0.20**	**0.36**	**1.9**	**N/A**	N/A				
	Draught proofing.	**13.09**	**0.34**	**0.14**	**0.09**	**3**	**246**	**0.10**	**0.07**	**0.6**	**N/A**	N/A				
	Controls for fridges, freezers & chilled appliances.	**13.30**	**0.13**	**0.07**	**0.11**	**2**	**72**	**0.04**	**0.06**	**1.6**	**N/A**	N/A				
	Swimming pool control improvements.	**12.71**	**0.72**	**0.30**	**0.08**	**10**	**338**	**0.14**	**0.04**	**0.3**	**N/A**	N/A				

Notes to replication potential assumptions

Major Refurb - the replication potential is assumed to be 35% of the total building stock in line with the major refurbishment objectives of the Building Schools for the Future programme.

Minor Refurb - the replication potential is assumed to be the lower of 15% of the total building stock (i.e. those buildings the will not be rebuilt or undergo major refurbishment) and modified according to the replication potential identified from previous school surveys. In the case of the swimming pool improvements the formula is applied only to those schools with pools. As mentioned in the previous section savings are based on 77% of the potential suggested by the survey sample.

Renewables - A take-up rate of 10% of the total school building stock to be refurbished (35%) has been assumed. The total floor area of the estate is equal to 56.3 million m^2 made up of 27.9 million m^2 primary and 28.4 milion m^2 secondary (used in this example) .

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 to Q4 2005.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).
Cost notes		Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate. The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.

Notional secondary school - Refurbishment (average floor area of existing estate 8574m^2)		Building Emissions Rating kgC/m^2/yr	Carbon Improvement Measures: Carbon saving kgC/m^2/yr	Energy Cost Saving £/m^2	Installed cost £/m^2 floor area	% Replication Potential - see notes	Overall Potential Savings tC	Overall potential cost saving £m	Overall installed cost (£m)	Simple payback period (yrs)	Simple payback period with 50% grant (yrs)	BREEAM Assessment: Target Emissions Rating kgC/m^2/yr	Part L pass or fail	% improvement over part L	Corresponding BREEAM score for credit E1 (2006 scheme)	BREEAM Score
Base School Evaluation		**13.43**														
Improvement Measure																
Major Refurbishment	1. Lighting – replace T12 with T5 throughout –average efficacy 100 lumens per circuit watt	**13.07**	**0.36**	**0.19**	**38.00**	**35**	**3579**	**1.90**	**377.78**	**198.4**	**N/A**	8.7	fail	-51%	0	**Good**
	2. Lighting controls – dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**13.04**	**0.39**	**0.21**	**0.87**	**35**	**3877**	**2.06**	**8.65**	**4.2**	**N/A**	8.7	fail	-50%	0	**Good**
	3. Lighting controls – occupancy sensing to corridors and toilets plus dimming from photoelectric cells (dependant on T5 tube improvement in 2 above	**12.93**	**0.50**	**0.27**	**1.27**	**35**	**4971**	**2.64**	**12.63**	**4.8**	**N/A**	8.7	fail	-49%	0	**Good**
	4. Upgrade heating – replace pre ECA standard boilers with post ECA standard	**11.03**	**2.40**	**0.99**	**3.29**	**35**	**23860**	**9.85**	**32.71**	**3.3**	**N/A**	8.7	fail	-27%	0	**Good**
	5. Single glazing replaced by 2005 specification double glazing (also assumes draughtproofing improvement)	**12.62**	**0.81**	**0.33**	**23.06**	**35**	**8053**	**3.33**	**229.25**	**68.9**	**N/A**	8.7	fail	-46%	0	**Good**
	6. Roof insulation – flat, no insulation replaced with 2005 regs compliant	**12.45**	**0.98**	**0.40**	**20.73**	**35**	**9743**	**4.02**	**206.09**	**51.2**	**N/A**	8.7	fail	-44%	0	**Good**
	7. Cavity wall insulation, blown balls, full fill	**11.01**	**2.42**	**1.00**	**7.82**	**35**	**24058**	**9.94**	**77.74**	**7.8**	**N/A**	8.7	fail	-27%	0	**Good**
	8.Post war -Cavity wall insulation, lighting T5 and controls, boiler and htg upgraded, double glazing.	**9.08**	**4.35**	**1.90**	**71.85**	**29**	**35832**	**15.65**	**591.84**	**37.8**	**N/A**	8.7	fail	-5%	0	**Good**
	9. As 8 plus new flat roof and insulation	**7.48**	**5.95**	**2.60**	**92.58**	**29**	**49011**	**21.41**	**762.60**	**35.6**	**N/A**	8.7	pass	14%	8	**Very Good**
	10 Pre-war (1945) pitched roof insulation increased to 250mm, double glazing, boiler and htg upgraded, lighting T5 and controls	**9.33**	**4.10**	**1.77**	**68.92**	**6**	**6987**	**3.01**	**117.46**	**39.0**	**N/A**	8.7	fail	-8%	0	**Good**

Major Refurb - the replication potential is assumed to be 35% of the total building stock in line with the major refurbishment objectives of the Building Schools for the Future programme.

Notes to replication potential assumptions

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Renewables - A take-up rate of 10% of the total school building stock to be refurbished (35%) has been assumed. The total floor area of the estate is equal to 56.3 million m^2 made up of 27.9 million m^2 primary and 28.4 milion m^2 secondary (used in this example).

Fuel price assumptions		**Notes**
fossil fuel p/kWh	2.14	Assumes 29.71% increase on 2003 statistics - inline with movements in DTI RPI index of gas prices over the period Q4 2003 to Q4 2005.
electricity p/kWh	6.24	Assumes 21.16% increase on 2003 statistics - inline with movements in DTI RPI index of electricity prices over the period Q4 2003 to Q4 2005.
biomass p/kWh	1.25	Based on good quality wood chip fuel (equivalent to £50/tonne @ 20% moisture content).
Cost notes		Installation costs given above are over-costs of installation i.e. they include and allowance for displaced plant where that is appropriate. The ground source heat pump, whilst it produces significant carbon savings, will not produce a payback during the life of the plant.

Appendix 3 – Rationale for BREEAM Scoring

BREEAM scores are based on a cross section of sustainability issues in the categories in the table below. Each section is weighted according to its relative importance in terms of sustainability, as can be seen from the table below. As one would expect, the combined energy and transport sections are the highest weighted and it is therefore necessary to score well in these sections to achieve a "Very Good" or "Excellent" BREEAM rating. In general, it is necessary to score at least 50% in all categories and much better than 50% in the higher weighted sections to achieve a BREEAM "Very Good".

Table of Credits assumed for Base Score

	Credits Available	Credits Achieved	% credits achieved	Weighting Factor	Full Assessment Score
Management	20.00	14.00	70.00	0.15	10.50
Health and wellbeing	19.00	15.00	78.95	0.15	11.84
Energy	18.00				0.00
Transport	6.00				0.00
subtotals		6.00	25.00	0.25	6.25
Water	7.00	7.00	100.00	0.05	5.00
Materials	17.00	8.00	47.06	0.10	4.71
Land use and Ecology	12.00	6.00	50.00	0.15	7.50
Pollution	14.00	6.00	42.85	0.15	6.42
			TOTAL	1.00	52.22

The score required for BREEAM "Very Good" is 55

The score required for BREEAM "Excellent" is 70

The table above also illustrates the typical assumed scores before the energy scoring is added.

The energy score under the BREEAM 2006 scheme, under which most BSF schools will be assessed, is based on a **Betterment** of compliance with the Building Regulations. If a school is just compliant, 0 or 1 credits out of 15 would be awarded, and additional credits would be gained as the energy performance increases as illustrated by the measures tables.

It should be noted that achieving BREEAM excellent is a very high standard, and not without capital cost implications.

To achieve a "Very Good" as a baseline without scoring significantly on energy has major implications on the design.

To construct the above table, the following broad assumptions were made

Management – the construction sustainable practices will be exemplary and the contractor will be prepared to invest significantly in monitoring and certification of site processes, commissioning and provision of information. The LEA and schools will undertake and fund extensive consultation and the design team will

be funded to be involved in this consultation and feedback as well as consultation with other bodies such as the crime prevention officer.

Health and Wellbeing – It has been assumed that schools assessed including refurbished schools will be shallow plan and have good window and ceiling heights to allow good daylighting throughout, ventilation schemes will allow excellent levels of ventilation with potential for natural ventilation and acoustic standards will meet, and for some areas, better BB93. It has been assumed that the site is not close to significant external noise such as motorways or flight paths – if this is the case, significant additional capital cost will be incurred in meeting the assumed standards. It has also been assumed that an extensive programme of acoustic testing will be funded. The sites chosen will not be close to significant sources of pollution, and chilled drinking water coolers will be provided throughout.

Energy – This is obviously the variable examined, but the base assumption is that extensive sub metering is provided. It would be highly unusual for a school to score very well without some contribution from the CO2 credit element of this section.

Transport – The provision of public transport is usually a “given” matter to a design team or developer and unless the LEA is prepared to invest in transport links or carry out extensive negotiation to bring transport to the site, where needed to score. Little can otherwise be done for sites where existing transport is poor. The base score therefore assumes moderate frequency of public transport, implemented green transport plan, cycle storage spaces and showers (this can be at significant cost and require additional space, particularly for primary schools), safe routes for cyclists and pedestrians.

Water – leakage detection, rainwater harvesting, low water use fittings and active management of water use is assumed.

Materials – this assumes Green Guide A rated materials for some but not all major elements as it is not always possible within cost guidelines to achieve all A rated – this would limit structural choices, and as a further example, preclude the extensive use of tarmac for external hard landscaping. Also in this section, reuse of materials and structure is scored and whilst this may be possible for refurbished schemes, in most school builds, where an existing school has to remain operational while the new one is built, reuse is impossible.

Land Use and ecology – again this is mostly a “given” element. The score assumes that the site is an existing school with playing fields, that the new school is built on the site, and that playing fields will be reinstated to the original area after completion of the scheme. It also assumes that significant funding will be in place for habitat enhancement and that an ecologist will be appointed and their recommendations followed. In general, all existing features such as trees and hedges will be retained and protected, although for many sites, this would not be possible.

Pollution – the score assumes that no refrigerants will be used, that low NOx emission boilers are used, that light pollution is minimised, and that insulants used avoid Hcfcs.

As can be concluded from the above, for a design team /developer to get to the baseline score, significant effort and investment will already have been made. It is possible to enhance the base score further, such that the school achieves a Very Good score before the effect of energy is added, but in reality, few sites would achieve this on assessment. Only three schools have completed assessment so far, and none have

achieved an excellent. It should also be noted that often on assessment evidence is not available to secure the BREEAM credit and there is often a 5% loss between the predicted and assessed rating.

In conclusion, the baseline score just below “Very Good”, without significant contribution from improved energy performance above Building Regulation compliance is justifiable and borne out by practical experience. It is possible to uplift the baseline score, without energy to 55, but the capital cost effect and effect on professional fees should not be ignored.