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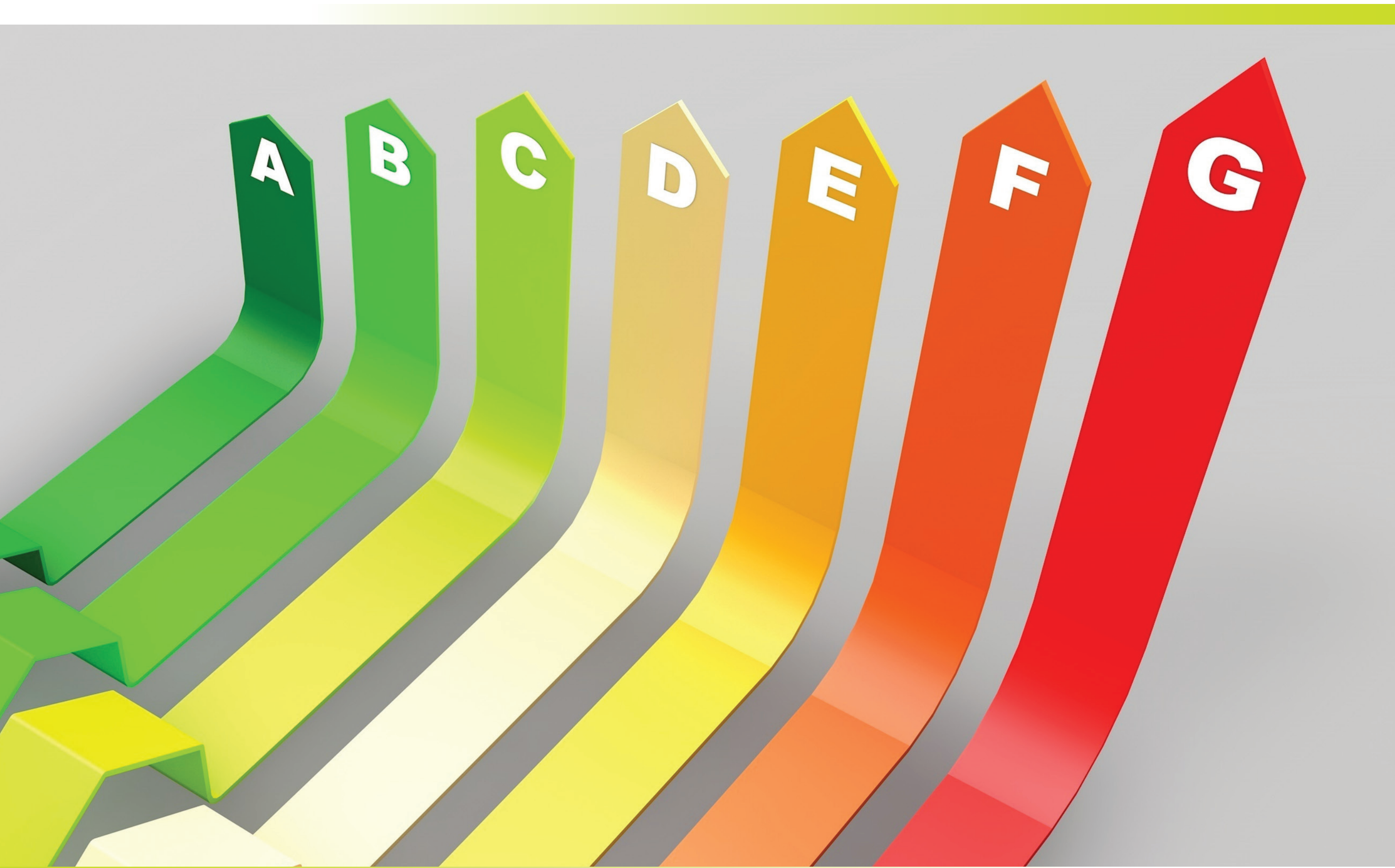
2014

National Association of Rooflight Manufacturers

Analysis of Improving Daylighting and Lighting Controls on a Number of Existing Non-Domestic Buildings

elmhurst energy

An independent report by Elmhurst Energy



Issued in conjunction with the National Association of Rooflight Manufacturers

Foreword

This report was commissioned by the National Association of Rooflight Manufacturers (NARM).

At the beginning of this century, the government set about improving the building stock of both new and existing non domestic buildings by addressing the Building Regulations Part L to reduce carbon emissions, by saving energy consumption on heating and lighting. In the early phases, the emphasis was on improving the building fabric by improving the buildings insulation. There were serious considerations at this time to reduce the windows and rooflights since these materials did not provide the same level of insulation as opaque areas.

NARM were already involved with the Government at the times and were able to demonstrate that the absence of good natural daylight into buildings resulted in an increase in power use due to the need for more electric lighting during the day which far outweighed the savings in heat energy for not using rooflights and glazing. It was also noted that if daylight levels are insufficient in non domestic buildings, the lights are turned on in the morning and stay on for the rest of the day as no one has the responsibility to turn them off.

Independent research was able to demonstrate that the optimum level of rooflighting (in appropriate buildings) was 15-20% of the floor area. This was incorporated into the energy calculations used by Part L2 together with the inclusions of improvements to lighting efficiency including dimming and automatic on/off control. It is now widely believed that the latest set of regulations, Part L2 2013, provide a building fabric and services that are at their most efficient. Further energy savings in 2016 and beyond will only be derived from renewable energy sources.

The purpose of this report is to focus on the existing building stock of non domestic buildings and to demonstrate that refurbishing/increasing rooflight areas to 15% and improving the efficiency of the lighting systems can be very effective with payback in just a few years. Medium term savings could be very substantial for the landowner and/or tenant. There is an added benefit on top of the financial and carbon savings – good, natural daylight in buildings improves the mood of people in the building and evidence shows they work more efficiently.

Contents

1.0 Summary

This report has undertaken analysis of three types of existing non domestic buildings to examine the effects of increasing the quality of day lighting and increasing the efficiency of electric lighting on both running costs and carbon emissions.

The buildings examined include an industrial building, a retail building, and a school. For each building the effect of improving the level of daylight (by use of improved rooflights and increased proportion of rooflights), improving the efficiency of the electric lighting system and improving the control of the lighting system have all been studied.

Each building type shows significant savings in both running cost and carbon emissions can be achieved using these improvements. This report details the overall savings available, together with the savings achieved by each measure independently, for each building type.

The results show savings in running costs of up to £5.92/m^2/yr, and savings of CO_2 emissions up to 28.7 kg CO_2/m^2/yr can be achieved, with results from industrial and retail buildings very consistent.

Slightly lower savings are achieved in the rooflit areas of the school (savings in running costs of £2.92/m^2/yr, and savings of CO_2 emissions of 14.7 kg CO_2/m^2/yr) primarily because significant sections of the rooflit areas are also well lit by windows, reducing the effect of improved illumination through rooflights.

In all 3 example buildings, the effect of improving daylighting through rooflights (by a combination of using more efficient modern rooflights, fitted to an appropriate percentage of the floor area) in conjunction with the existing electric lighting system offers a significantly greater saving (typically twice as great a saving) than improving the efficiency of the electric lighting system in conjunction with the existing rooflights. However, the greatest savings are achieved by a combination of all measures: improving the rooflights to increase the amount of light entering a building and adding automatic lighting controls to modern, more efficient light fittings.

2.0 Introduction

The main focus of the analysis is to identify opportunities to make energy savings and carbon reductions on the existing UK industrial and commercial building stock by increasing the amount of natural light entering buildings, improving lighting systems and adding automatic control of lighting systems. The analysis focused on a series of three existing case-study buildings which were selected to represent a range of sectors including education, retail and industrial.

The project was designed to explore the impact of a number of improvement measures for each building type with the aim of illustrating the potential of improving daylight through rooflights and upgrading lighting fittings and control systems in existing non domestic buildings.

Analysis of each building included predicted reduction in energy use, associated carbon emissions and operating costs for each building.

This report provides an overview of the analysis undertaken and findings to date.

3.0 Methodology

Analysis was undertaken to assess the existing energy efficiency of the selected buildings and model suitable improvements to rooflights, lighting systems and lighting controls. This was achieved from a combination of surveys of the case-study buildings and modelling of their energy performance with various improvements using an energy modelling tool.

The iSBEM (version 4.1e) software package was selected as the energy modelling tool. iSBEM 4.1e is based on the Simplified Building Energy Model (SBEM) methodology developed by the BRE. This model aligns with the requirements of the Building Regulations 2010 and is widely understood and used throughout the industry.

These aspects of the methodology are discussed further below.

3.01 Selection of Buildings

The buildings studied were selected to wherever possible to meet the ‘types’ defined as follows:

1. **Primary School** – Typical primary school, similar to a “CLASP” design as this appears to be a type which represents the majority of school buildings. Ideal floor area for assessment between 500-1000m^2.
2. **Industrial** – Industrial unit with space heating, preferably with roof lights and larger than 1500 sq. m floor area.

3. **Retail Building** – Self-contained Retail unit ideally no more than 2000 sq. m floor area.

In addition to representative building types the following characteristics were also taken into account when selecting each of the buildings:

- The owner and / or occupier agrees for the project team to use the building in the study and provide access for the survey (non-destructive) of the buildings fabric, occupancy, and services in the required timeframes.
- All buildings contain areas that have rooflights.
- Ensure that the buildings were NOT listed or in a conservation area or other areas subject to planning approval sensitivities.
- Located in England or Wales.

3.02 Hierarchy of Improvements

Elmhurst Energy in cooperation with the National Association of Rooflight Manufacturers (NARM) has created a range of scenarios to apply to the existing buildings that were assessed. These scenarios were created to demonstrate the impact of increasing the quality of daylight within buildings via rooflights and/or improving the existing lighting systems and controls on carbon emissions, costs and energy use;

Scenario-1: Existing building

Surveys were completed on all three existing buildings and assessed using iSBEM 4.1e software package. These results were based on some assumptions for the date of construction of the buildings and were the starting point of the analysis.

Scenario-2: Improved existing lighting controls

Taking the model from Scenario 1, an on-off automatic photoelectric control system was added for the existing lights.

Scenario-3: Improved rooflights

Taking the model from Scenario 2 the new rooflights were modelled to the following conditions;

1. For any zones where a rooflight area of less that 15% of the floor area, rooflight area set to 15% of the floor area of the zone
2. New rooflights u-value changed to 1.7 W/m^{2}K
3. L-solar set to 0.65 and T-solar set to 0.62

Scenario-4: Advanced lighting controls

Taking the model from Scenario 3 including the replacement rooflights, the lighting control system was further improved by adjusting the automatic photoelectric control system to a proportional dimming system.

Scenario-5: Improved light fittings

Revert back to Scenario 2 with the original rooflights, the existing lighting was upgraded to T5 fluorescent units.

Scenario-6: Improved light fittings and advanced controls

Take Scenario 5 with the original rooflights, further improve the lighting control system by adjusting the automatic photoelectric control system to a proportional dimming system.

Scenario-7: Improved rooflights, lighting and light controls

Combine Scenario 3 and 6 to give a total improvement based on new rooflights, light fittings and lighting controls.

3.03 Carbon Saving Analysis

Using the data from the range of scenarios described, the carbon emissions were calculated on the iSBEM software. The iSBEM 4.1e software uses the following factors for calculation of carbon emissions;

Fuel Type	$kgCO_2/kWh$
Mains Gas	0.198
Electricity	0.517

Figure 1: $kgCO_2/kWh$ taken from Table 12 SAP 2009 Document

3.04 Cost Savings Analysis

Using the data from the range of scenarios listed in section 2.03 an evaluation of cost saving was made. This was based on the cost in pence per kWh for mains gas and grid electricity used in iSBEM 4.1e;

Fuel Type	p/kWh
Mains Gas	3.1
Electricity	11.46

Figure 2: p/kWh taken from Table 12 SAP 2009 Document

4.0 Homebase Store

The results show that for the Homebase store, total carbon emissions could be reduced by 29% and total operating costs could be reduced by 33%.

These saving equate to:

- a reduction of 24.1 $kgCO_2/m^2/yr$
  - in this example giving a building wide saving of 94709 $kgCO_2$/year
- a reduction in total operating costs of £5.20/m^2/yr
  - in this example giving a building wide saving of £20,435 per annum.

These overall savings comprise both reductions in use of the heating system (through better insulated replacement rooflights) and reductions in use of the lighting system (through better control systems, more efficient electric lights, and better availability of natural light through replacement rooflights.

Reduced use of the lighting system accounts for 91% of the total saving in carbon emissions and 94% of the total cost saving, with the remainder coming from reduced use of the heating system

The overall savings also comprise contributions from improved efficiency of electric light systems, better automatic lighting control systems, and replacement rooflights (with higher light transmission, better insulation, and potentially fitted to greater areas) to provide better quality natural daylight.

Improvements to the rooflights and lighting control systems (where this is technically possible whilst retaining existing electric lights) offers:

- savings of 29% in carbon emissions (23.5 $kgCO_2/m^2/yr$)
- savings of 32% in total running costs (£5.05/m^2/yr)

In this example, improvements to electric lights and lighting control systems whilst retaining existing rooflights offers:

- savings of 11% in carbon emissions (9.3 $kgCO_2/m^2/yr$)
- savings of 14% in total running costs (£2.13/m^2/yr)

However, to gain the full potential savings requires improvements to all 3 aspects: rooflights, lighting systems, and automatic control of the lighting systems.

Following on from the improvement scenarios listed above the results were correlated into graphs to show the impact of the improvements on the running costs of the building;

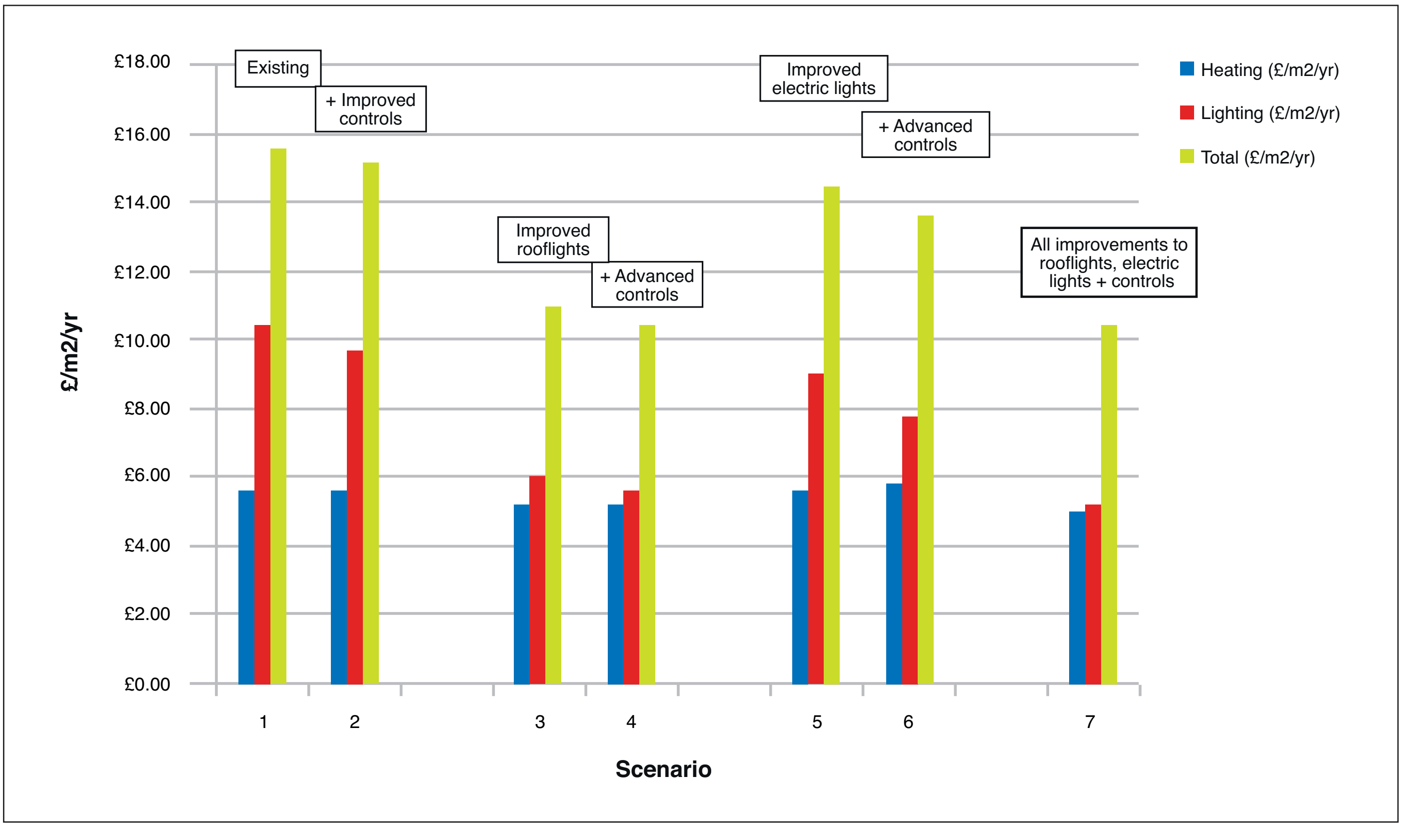


Figure 3: Reduction in operating costs at Homebase Store

5.0 Lunn Engineering

The results show that for the Lunn Engineering, total carbon emissions could be reduced by 26% and total operating costs could be reduced by 30%.

These saving equate to:

- a reduction of 28.7 $kgCO_2/m^2/yr$
  - in this example giving a building wide saving of 28529.81 $kgCO_2$/year
- a reduction in total operating costs of £5.92/m^2/yr
  - in this example giving a building wide saving of £5884.89 per annum.

These overall saving comprise both reductions in use of the heating system (through better insulated replacement rooflights) and reductions in use of the lighting system (through better control systems, more efficient electric lights, and better availability of natural light through replacement rooflights.

Reduced use of the lighting system accounts for 77% of the total saving in carbon emissions and 82% of the total cost saving, with the remainder coming from reduced use of the heating system

The overall savings also comprise contributions from improved efficiency of electric light systems, better automatic lighting control systems, and replacement rooflights (with higher light transmission, better insulation, and potentially fitted to greater areas) to provide better quality natural daylight.

Improvements to the rooflights and lighting control systems (where this is technically possible whilst retaining existing electric lights) offers:

- savings of 23% in carbon emissions (25.8 $kgCO_2/m^2/yr$)
- savings of 26% in total running costs (£5.22/m^2/yr)

In this example, improvements to electric lights and lighting control systems whilst retaining existing rooflights offers:

- savings of 14% in carbon emissions (15.3 $kgCO_2/m^2/yr$)
- savings of 18% in total running costs (£3.64/m^2/yr)

However, to gain the full potential savings requires improvements to all 3 aspects: rooflights, lighting systems, and automatic control of the lighting systems.

Following on from the improvement scenarios listed above the results were correlated into graphs to show the impact of the improvements on the running costs of the building;

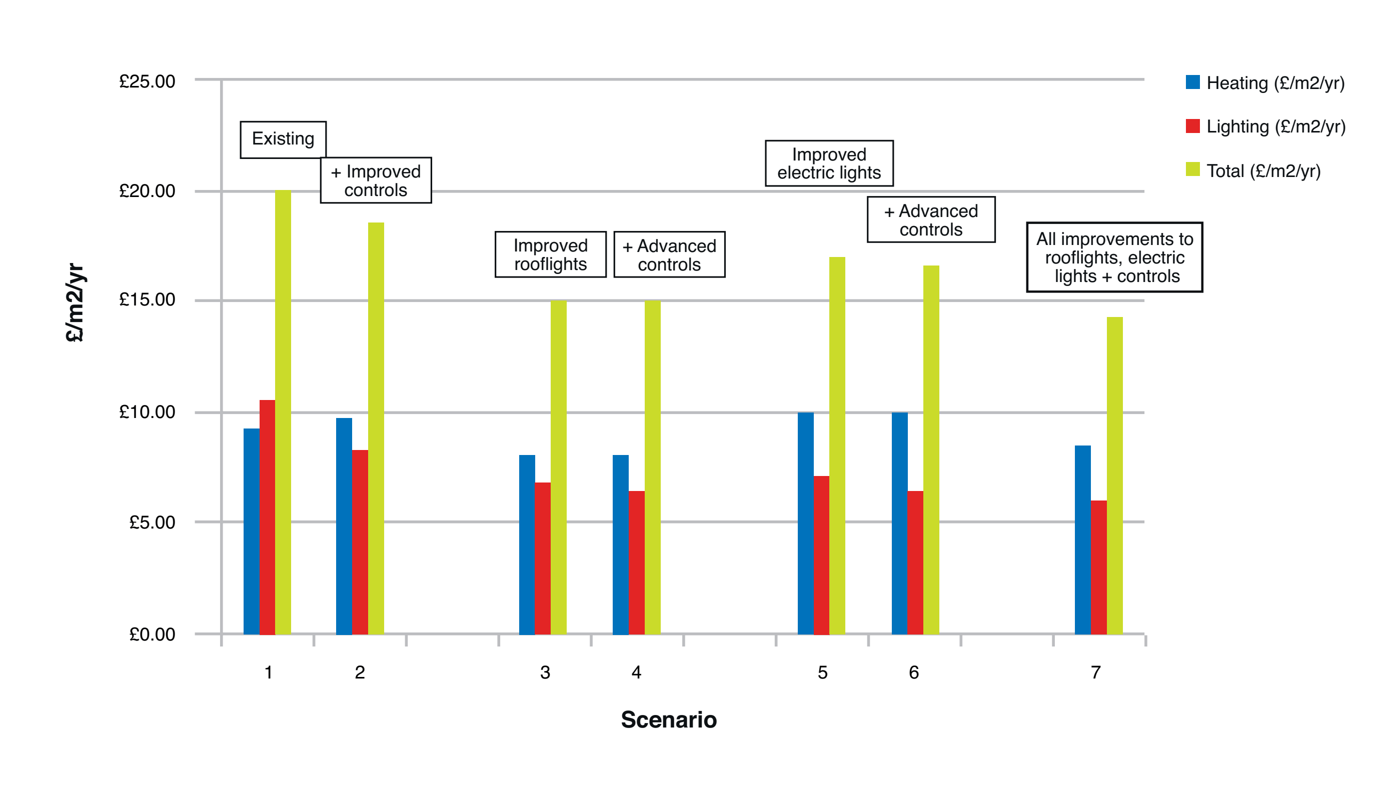


Figure 4: Reduction in operating costs at Lunn Engineering

6.0 Ovingham School

The results show that for the Ovingham School, total carbon emissions could be reduced by 9.1% and total operating costs could be reduced by 19%.

These saving equate to:

- a reduction of 7.3 $kgCO_2/m^2/yr$
  - in this example giving a building wide saving of 11796.8 $kgCO_2$/year
- a reduction in total operating costs of £1.50/m^2/yr
  - in this example giving a building wide saving of £2424 per annum.

These overall saving comprise both reductions in use of the heating system (through better insulated replacement rooflights) and reductions in use of the lighting system (through better control systems, more efficient electric lights, and better availability of natural light through replacement rooflights.

Reduced use of the lighting system accounts for 76% of the total saving in carbon emissions and 82% of the total cost saving, with the remainder coming from reduced use of the heating system

The overall savings also comprise contributions from improved efficiency of electric light systems, better automatic lighting control systems, and replacement rooflights (with higher light transmission, better insulation, and potentially fitted to greater areas) to provide better quality natural daylight.

Improvements to the rooflights and lighting control systems (where this is technically possible whilst retaining existing electric lights) offers:

- savings of 8.9% in carbon emissions (7.1 $kgCO_2/m^2/yr$)
- savings of 18.5% in total running costs (£1.45/m^2/yr)

In this example, improvements to electric lights and lighting control systems whilst retaining existing rooflights offers:

- savings of 3.7% in carbon emissions (3 $kgCO_2/m^2/yr$)
- savings of 9.6% in total running costs (£0.75/m^2/yr)

However, to gain the full potential savings requires improvements to all 3 aspects: rooflights, lighting systems, and automatic control of the lighting systems.

The savings shown are significantly lower than in the previous two example buildings, because only 51.4% of the floor area of the school is in rooflit zones, so the improvements studied only affect about half of the total building.

These savings therefore equate to a saving of £2.92/m²/yr in running costs, and savings of 28.7kgCO_2/m²/yr in CO_2 emissions, for the areas which are rooflit.

These savings are still lower than the previous two examples, primarily because many of the rooflit areas (particularly classrooms) are also well lit by windows for the areas near glazed walls. They are therefore well illuminated before any changes are made, so that improvements to rooflights in these particular areas have less effect than they do in other areas.

Following on from the improvement scenarios listed above the results were correlated into graphs to show the impact of the improvements on the running costs of the building;

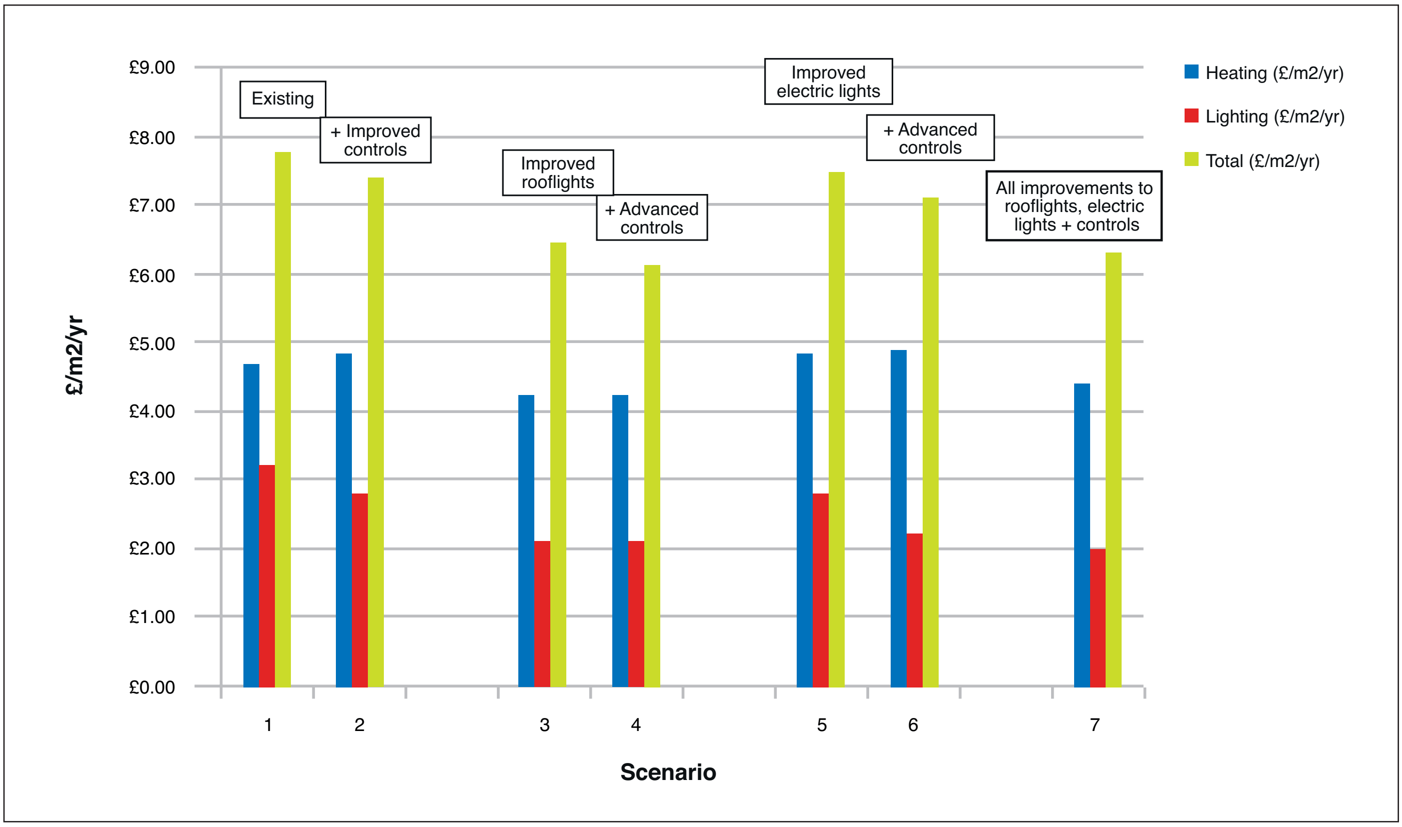


Figure 5: Reduction in operating costs at Ovingham School

Appendices

Appendix Contents

Appendix A: Homebase Store Calculation Details

Photograph of building

Illustration of refurbished building

Building Introduction

1. **General**
   a. It has total floor area of 3930 m^2.
   b. The building comprises a large retail area with separate toilet and office facilities.

2. **Building Fabric**
   a. The existing building envelope consists of uninsulated metal clad (u-value 1.3) and cavity walls (estimated u-value 1.6).
   b. An uninsulated ground floor (estimated u-value 0.58).
   c. Roof over the whole area (estimated u-value 0.45).
   d. Single glazed windows (estimated u-value 6.21) and rooflights (estimated u-value 4.51).
   e. Estimated air tightness of 25 $m^3/hr/m^2$.

3. **Services**
   a. The existing building services include a gas fired convector system (estimated 75% efficient) and LTHW boiler to radiators (estimated 65% efficient).
   b. The office and toilets have fluorescent tube T8 light fittings (estimated efficiency 64 lumens/watt), the retail area has metal halide light fittings (estimated efficiency 60 lumens/watt).

Homebase Store – Existing Rooflights and Lighting Systems

1) Existing Rooflights

The store has a total rooflight area of area of 331.33 m^2. The following table shows how the rooflights are spread around the building;

Zone Summary Calculations						
	TFA (m^2)	**Actual RL area (m^2)**	**Actual %**	**15% (m^2)**	**Zone Type**	**Window area (m^2)**
Z0/01	3676.1	331.33	9.01	551.42	Retail warehouse sales	43.62
Z0/02	126.9	0	0	0	Toilets	0
Z0/01	126.9	0	0	0	Office	0
Totals (m^2)	3929.9	331.33				43.62
			Rooflights present			

2) Lighting

The store has a mixture of T8 fluorescent light fittings in the office and toilets and metal halide fittings in the retail area with no automatic control systems present.

Homebase Store Scenario 1: Existing Building

The following is the list of improvements made to the building as part of this Retro-fit strategy:

Predicted energy performance following retrofit:

Homebase Store Scenario 1

	Heating (kWh/ m^2)	Auxiliary (kWh/ m^2)	Lighting (kWh/ m^2)	DHW (kWh/ m^2)	Total (kWh/ m^2)	Improvement (% over existing kWh/ m^2)	Kg/ CO_2/ m^2/yr	Improvement (% over existing kg/ CO_2/ m^2/yr)	EPC Rating
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B

Homebase Store Scenario 2: Improved existing lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 1.
2. **Lighting controls:**
   - In zones with rooflights, photoelectric controls were added with simple on-off automatic control.

Predicted energy performance following retrofit:

Homebase Store Scenario 2									
	Heating (kWh/m^2)	**Auxiliary (kWh/m^2)**	**Lighting (kWh/m^2)**	**DHW (kWh/m^2)**	**Total (kWh/m^2)**	**Improvement (% over existing kWh/m^2)**	**$Kg/CO_2/m^2/yr$**	**Improvement (% over existing $kg/CO_2/m^2/yr$)**	**EPC Rating**
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B

Homebase Store Scenario 3: Improved rooflights

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - For all zones with rooflight area that is less than 15% of the zone floor area, increase rooflight area to 15% of floor area of the zone.
   - Improve the u-value of the rooflights to 1.7 w/m^{2}k.
   - Change the t-solar to 0.62.
   - Change the frame factor of the rooflights to 0.0.
   - Set the Surface area ratio of the rooflights to 1.0.
2. **Lighting controls:**
   - As per spec Scenario 2.

Predicted energy performance following retrofit:

Homebase Store Scenario 3									
	Heating (kWh/m^2)	**Auxiliary (kWh/m^2)**	**Lighting (kWh/m^2)**	**DHW (kWh/m^2)**	**Total (kWh/m^2)**	**Improvement (% over existing kWh/m^2)**	**Kg/CO_2/m^2/yr**	**Improvement (% over existing kg/CO_2/m^2/yr)**	**EPC Rating**
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B
Scenario 3	161.71	1.73	52.58	2.81	218.84	18.79%	60.7	26.25%	37B

Homebase Store Scenario 4: Advanced lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   – As per spec Scenario 3.
2. **Lighting controls:**
   – In zones with photoelectric controls, improve the system to a proportional dimming system.

Predicted energy performance following retrofit:

Homebase Store Scenario 4									
	Heating (kWh/m²)	**Auxiliary (kWh/m²)**	**Lighting (kWh/m²)**	**DHW (kWh/m²)**	**Total (kWh/m²)**	**Improvement (% over existing kWh/m²)**	**Kg/CO_2/m²/yr**	**Improvement (% over existing kg/CO_2/m²/yr)**	**EPC Rating**
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B
Scenario 3	161.71	1.73	52.58	2.81	218.84	18.79%	60.7	26.25%	37B
Scenario 4	163.82	1.73	48.06	2.81	216.42	19.68%	58.7	28.68%	36B

Homebase Store Scenario-5: Improved light fittings

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   – As per Scenario 2.
2. **Lighting controls:**
   – As per spec Scenario 2.
3. **Lighting:**
   – Upgrade the current light fittings to T5 fluorescent fittings.

Homebase Store Scenario 5

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B
Scenario 3	161.71	1.73	52.58	2.81	218.84	18.79%	60.7	26.25%	37B
Scenario 4	163.82	1.73	48.06	2.81	216.42	19.68%	58.7	28.68%	36B
Scenario 5	178.22	1.73	78.49	2.81	261.26	3.04%	77.3	6.08%	47B

Homebase Store Scenario 6: Improved light fittings and advanced controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per spec Scenario 2.
2. **Lighting controls:**
   - In zones with photoelectric controls, improve the system to a proportional dimming system.
3. **Lighting:**
   - As per spec Scenario 5.

Homebase Store Scenario 6

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B
Scenario 3	161.71	1.73	52.58	2.81	218.84	18.79%	60.7	26.25%	37B
Scenario 4	163.82	1.73	48.06	2.81	216.42	19.68%	58.7	28.68%	36B
Scenario 5	178.22	1.73	78.49	2.81	261.26	3.04%	77.3	6.08%	47B
Scenario 6	181.75	1.73	68.69	2.81	254.97	5.38%	72.9	11.42%	44B

Homebase Store Scenario-7: Improved rooflights, lighting and light controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 3.
2. **Lighting controls:**
   - As per Scenario 6.
3. **Lighting:**
   - As per Scenario 6.

Homebase Store Scenario 6

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	175.03	1.73	89.09	2.81	268.66	0.3%	82.2	0.13%	50B
Scenario 2	175.73	1.73	84.98	2.81	265.25	1.56%	80.2	2.55%	49B
Scenario 3	161.71	1.73	52.58	2.81	218.84	18.79%	60.7	26.25%	37B
Scenario 4	163.82	1.73	48.06	2.81	216.42	19.68%	58.7	28.68%	36B
Scenario 5	178.22	1.73	78.49	2.81	261.26	3.04%	77.3	6.08%	47B
Scenario 6	181.75	1.73	68.69	2.81	254.97	5.38%	72.9	11.42%	44B
Scenario 7	164.58	1.73	46.5	2.81	215.62	19.98%	58.1	29.4%	35B

Appendix B: Lunn Engineering Calculation Details

Photograph of building

Illustration of refurbished building

Building Introduction

1. **General**
    a. An industrial process building, comprising an office area and metal working area, located in North Warwickshire, and originally constructed in the 1960's.
    b. The building is occupied by around 30 staff members.
    c. It has total floor area of 994 m^2.
    d. The envelope of the process area is generally in a very poor state.
    e. Very high heating and lighting demands due to poorly insulated envelope and old lighting systems.

2. **Building Fabric**
    a. The existing building envelope consists of insulated asbestos sheet (u-value 0.6) and cavity walls (u-value 1.6).
    b. An uninsulated ground floor (estimated u-value 0.58).
    c. An insulated asbestos roof over the process area (estimated u-value 0.61) and a poorly insulated flat roof over the office area (estimated u-value 2.8).
    d. Single glazed rooflights (estimated u-value 6.3).
    e. Estimated air tightness of 35 $m^3/hr/m^2$.

3. **Services**
    a. The existing building services include a gas warm air blower system in the process area (estimated 75% efficient) and1980's gas boiler system in the office area (78.5% efficient).
    b. The process area has fluorescent tube T12 light fittings (estimated efficiency 60 lumens/watt), the office area has tungsten light fittings (estimated efficiency 12 lumens/watt).

Lunn Engineering – Existing Rooflights and Lighting Systems

1) Existing Rooflights

The building has a total rooflight area of area of 121.64 m². The following table shows how the rooflights are spread around the building;

Zone Summary Calculations						
	TFA (m²)	**Actual RL area (m²)**	**Actual %**	**15% (m²)**	**Zone Type**	**Window area (m²)**
Z0/01	2.15	0	0	0	Reception	3.49
Z0/02	86.58	0	0	0	Office	16.67
Z0/03	17.96	0	0	0	Toilets	3.68
Z0/04	9.49	0	0	0	Eating/drinking area	1.49
Z0/05	99.09	20	20.18	14.86	Industrial process	0
Z0/06	41.27	0	0	0	Store	0
Z0/07	444.92	69.24	15.56	66.74	Industrial process	0
Z0/08	292.6	32.4	11.07	43.89	Industrial process	5.25
Totals (m²)	994.06	121.64				30.58
	Rooflights present					

2) Lighting

The building has existing T12 fluorescent light fittings with no automatic control systems present in the process areas and tungsten fittings in the small office areas.

Lunn Engineering Scenario 1: Existing buildings

Predicted energy performance following retrofit:

Lunn Engineering Scenario 1									
	Heating (kWh/m^2)	**Auxiliary (kWh/m^2)**	**Lighting (kWh/m^2)**	**DHW (kWh/m^2)**	**Total (kWh/m^2)**	**Improvement (% over existing kWh/m^2)**	**$Kg/CO_2/m^2/yr$**	**Improvement (% over existing $kg/CO_2/m^2/yr$)**	**EPC Rating**
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E

Lunn Engineering Scenario 2: Improved existing lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 1.
2. **Lighting controls:**
   - In zones with rooflights, photoelectric controls were added with simple on-off automatic control.

Predicted energy performance following retrofit:

Lunn Engineering Scenario 2									
	Heating (kWh/m²)	**Auxiliary (kWh/m²)**	**Lighting (kWh/m²)**	**DHW (kWh/m²)**	**Total (kWh/m²)**	**Improvement (% over existing kWh/m²)**	**Kg/CO_2/m²/yr**	**Improvement (% over existing kg/CO_2/m²/yr)**	**EPC Rating**
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D

Lunn Engineering Scenario 3: Improved rooflights

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - For all zones with rooflight area that is less than 15% of the zone floor area, increase rooflight area to 15% of floor area of the zone.
   - Improve the u-value of the rooflights to 1.7 w/m^{2}k.
   - Change the t-solar to 0.62.
   - Change the frame factor of the rooflights to 0.0.
   - Set the Surface area ratio of the rooflights to 1.0.
2. **Lighting controls:**
   - As per Scenario 2.

Predicted energy performance following retrofit:

Lunn Engineering Scenario 3

	Heating (kWh/m^2)	Auxiliary (kWh/m^2)	Lighting (kWh/m^2)	DHW (kWh/m^2)	Total (kWh/m^2)	Improvement (% over existing kWh/m^2)	Kg/CO_2/m^2/yr	Improvement (% over existing kg/CO_2/m^2/yr)	EPC Rating
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D
Scenario 3	266.92	5.17	59.6	6.08	337.76	18.19%	87.5	22.36%	82D

Lunn Engineering Scenario 4: Advanced lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   – As per Scenario 3.
2. **Lighting controls:**
   – In zones with photoelectric controls, improve the system to a proportional dimming system.

Predicted energy performance following retrofit:

Lunn Engineering Scenario 4									
	Heating (kWh/ m²)	**Auxiliary (kWh/m²)**	**Lighting (kWh/m²)**	**DHW (kWh/ m²)**	**Total (kWh/ m²)**	**Improvement (% over existing kWh/ m²)**	**Kg/CO_2/ m²/yr**	**Improvement (% over existing kg/ CO_2/m²/yr)**	**EPC Rating**
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D
Scenario 3	266.92	5.17	59.6	6.08	337.76	18.19%	87.5	22.36%	82D
Scenario 4	268.7	5.17	57.03	6.08	336.98	18.28%	86.6	23.16%	81D

Lunn Engineering Scenario 5: Improved light fittings

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 2.
2. **Lighting controls:**
   - As per Scenario 2.
3. **Lighting:**
   - Upgrade the current light fittings to T5 fluorescent fittings.

Lunn Engineering Scenario 5

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D
Scenario 3	266.92	5.17	59.6	6.08	337.76	18.19%	87.5	22.36%	82D
Scenario 4	268.7	5.17	57.03	6.08	336.98	18.28%	86.6	23.16%	81D
Scenario 5	323.82	5.17	59.39	6.08	394.46	4.34%	98.7	12.42%	92D

Lunn Engineering Scenario 6: Improved light fittings and advanced controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 2.
2. **Lighting controls:**
   - In zones with photoelectric controls, improve the system to a proportional dimming system.
3. **Lighting:**
   - As per Scenario 5.

Lunn Engineering Scenario 6

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D
Scenario 3	266.92	5.17	59.6	6.08	337.76	18.19%	87.5	22.36%	82D
Scenario 4	268.7	5.17	57.03	6.08	336.98	18.28%	86.6	23.16%	81D
Scenario 5	323.82	5.17	59.39	6.08	394.46	4.34%	98.7	12.42%	92D
Scenario 6	326.71	5.17	55.18	6.08	393.14	4.66%	97.1	13.84%	91D

Lunn Engineering Scenario 7: Improved rooflights, lighting and light controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 3.
2. **Lighting controls:**
   - As per Scenario 6.
3. **Lighting:**
   - As per Scenario 6.

Lunn Engineering Scenario 7

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	307	5.17	92.27	6.08	410.52	0.45%	112.4	0.27%	105E
Scenario 2	315.37	5.17	71.62	6.08	398.24	3.42%	103.3	8.34%	96D
Scenario 3	266.92	5.17	59.6	6.08	337.76	18.19%	87.5	22.36%	82D
Scenario 4	268.7	5.17	57.03	6.08	336.98	18.28%	86.6	23.16%	81D
Scenario 5	323.82	5.17	59.39	6.08	394.46	4.34%	98.7	12.42%	92D
Scenario 6	326.71	5.17	55.18	6.08	393.14	4.66%	97.1	13.84%	91D
Scenario 7	273.4	5.17	49.66	6.08	334.32	18.93%	83.7	25.73%	78D

Appendix C: Ovingham School Calculation Details

Photograph of building

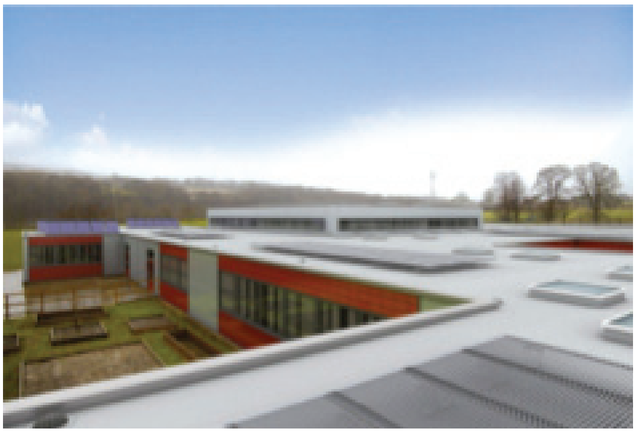


Illustration of refurbished building

Building Introduction

1. **General**
   a. Ovingham School is existing 1970's build primary school located in Northumberland.
   b. The school is occupied by around 400 children with a floor area of 1600 m^2.

2. **Building Fabric**
   a. The existing building envelope consists of uninsulated cavity walls (estimated U value 1.7).
   b. Curtain walls with asbestos panels (estimated U value 2.3).
   c. A flat roof (estimated U value 0.68*), a solid floor (estimated U value 0.53).
   d. Single glazed fenestration (estimated U value 6.21).
   e. Estimated air tightness of 25 $m^3/hr/m^2$.

3. **Services**
   a. The existing building services include a 1970's gas boiler system (estimated efficiency 65%).
   b. A gas water heater (estimated efficiency 75%).
   c. Fluorescent tube T12 light fittings (estimated efficiency 60 lumens/watt).

Ovingham School – Existing Rooflights and Lighting Systems

1) Existing Rooflights

The school has a total rooflight area of area of 32.66 m^2. The following table shows how the rooflights are spread around the building;

Zone Summary Calculations

	TFA (m^2)	Actual RL area (m^2)	Actual RL %	Zone Type	Window area (m^2)
Z0/01	298.7	6.48	2.17	Teaching area	65.95
Z0/02	161.83	0	0	Circulation	6.88
Z0/03	31.24	6	19.21	Changing rooms	0
Z0/04	185.5	8	4.31	Workshop	0
Z0/05	31.24	6	19.21	Changing rooms	0
Z0/06	48.99	0	0	Circulation	1.8
Z0/07	37.44	0	0	Computer Lab	9.29
Z0/08	76.81	1	1.3	Teaching area	19.9
Z0/09	114.9	2.43	2.11	Eating/drinking area	10.98
Z0/10	17	0	0	Toilets	0
Z0/11	8	1	12.5	Circulation	0
Z0/12	42.71	0	0	Office	13.94
Z0/13	36.48	0	0	Office	2.64
Z0/14	87	1.75	2.01	Food preparation	18.83
Z0/15	27.52	0	0	Plant room	0
Z0/16	61.56	0	0	Changing rooms	0
Z0/17	18	0	0	Circulation	0
Z0/18	116.18	0	0	Teaching area	0
Z0/19	149.34	0	0	Dry sports hall	59.1
Z0/20	70.38	0	0	Teaching area	27
Totals (m^2)	1620.82	32.66			236.31
	Rooflights present				

2) Lighting

The school has existing T12 fluorescent light fittings with no automatic control systems present.

Ovingham School Scenario 1: Existing Buildings

Predicted energy performance following retrofit:

Ovingham School Scenario 1									
	Heating (kWh/ m^2)	**Auxiliary (kWh/m^2)**	**Lighting (kWh/m^2)**	**DHW (kWh/ m^2)**	**Total (kWh/ m^2)**	**Improvement (% over existing kWh/ m^2)**	**Kg/CO_2/ m^2/yr**	**Improvement (% over existing kg/ CO_2/m^2/yr)**	**EPC Rating**
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C

Ovingham School Scenario 2: Improved existing lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 1.
2. **Lighting controls:**
   - In zones with rooflights, photoelectric controls were added with simple on-off automatic control.

Predicted energy performance following retrofit:

Ovingham School Scenario 2									
	Heating (kWh/m^2)	**Auxiliary (kWh/m^2)**	**Lighting (kWh/m^2)**	**DHW (kWh/m^2)**	**Total (kWh/m^2)**	**Improvement (% over existing kWh/m^2)**	**$Kg/CO_2/m^2/yr$**	**Improvement (% over existing $kg/CO_2/m^2/yr$)**	**EPC Rating**
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C

Ovingham School Scenario 3: Improved rooflights

The following shows the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - For all zones with rooflight area that is less than 15% of the zone floor area, increase rooflight area to 15% of floor area of the zone.
   - Improve the u-value of the rooflights to 1.7 w/m²k.
   - Change the t-solar to 0.62.
   - Change the frame factor of the rooflights to 0.0.
   - Set the Surface area ratio of the rooflights to 1.0.
2. **Lighting controls**:
   - As per Scenario 2.

Predicted energy performance following retrofit:

Ovingham School Scenario 3									
	Heating (kWh/m²)	**Auxiliary (kWh/m²)**	**Lighting (kWh/m²)**	**DHW (kWh/m²)**	**Total (kWh/m²)**	**Improvement (% over existing kWh/m²)**	**Kg/CO_2/m²/yr**	**Improvement (% over existing kg/CO_2/m²/yr)**	**EPC Rating**
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C
Scenario 3	138.9	5.4	18.42	152.63	315.36	5.83%	73.3	8.6%	58C

Ovingham School Scenario 4: Advanced lighting controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 3.
2. **Lighting controls:**
   - In zones with photoelectric controls, improve the system to a proportional dimming system.

Predicted energy performance following retrofit:

Ovingham School Scenario 4									
	Heating (kWh/m²)	**Auxiliary (kWh/m²)**	**Lighting (kWh/m²)**	**DHW (kWh/m²)**	**Total (kWh/m²)**	**Improvement (% over existing kWh/m²)**	**Kg/CO_2/m²/yr**	**Improvement (% over existing kg/CO_2/m²/yr)**	**EPC Rating**
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C
Scenario 3	138.9	5.4	18.42	152.63	315.36	5.83%	73.3	8.6%	58C
Scenario 4	139.5	5.4	17.88	152.63	315.41	5.81%	73.1	8.85%	58C

Ovingham School Scenario 5: Improved light fittings

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   – As per Scenario 2.
2. **Lighting controls:**
   – As per Scenario 2.
3. **Lighting:**
   – Upgrade the current light fittings to T5 fluorescent fittings.

Ovingham School Scenario 5

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C
Scenario 3	138.9	5.4	18.42	152.63	315.36	5.83%	73.3	8.6%	58C
Scenario 4	139.5	5.4	17.88	152.63	315.41	5.81%	73.1	8.85%	58C
Scenario 5	153.07	5.4	23.44	152.63	334.56	0.09%	78.7	1.87%	63C

Ovingham School Scenario 6: Improved light fittings and advanced controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 2.
2. **Lighting controls:**
   - In zones with photoelectric controls, improve the system to a proportional dimming system.
3. **Lighting:**
   - As per Scenario 5.

Ovingham School Scenario 6

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C
Scenario 3	138.9	5.4	18.42	152.63	315.36	5.83%	73.3	8.6%	58C
Scenario 4	139.5	5.4	17.88	152.63	315.41	5.81%	73.1	8.85%	58C
Scenario 5	153.07	5.4	23.44	152.63	334.56	0.09%	78.7	1.87%	63C
Scenario 6	154.9	5.4	19.8	152.63	332.74	0.64%	77.2	3.74%	61C

Ovingham School Scenario 7: Improved rooflights, lighting and light controls

The following is the list of improvements made to the building as part of this Retro-fit strategy:

1. **Rooflights:**
   - As per Scenario 3.
2. **Lighting controls:**
   - As per Scenario 6.
3. **Lighting:**
   - As per Scenario 6.

Ovingham School Scenario 7

	Heating (kWh/m²)	Auxiliary (kWh/m²)	Lighting (kWh/m²)	DHW (kWh/m²)	Total (kWh/m²)	Improvement (% over existing kWh/m²)	Kg/CO_2/m²/yr	Improvement (% over existing kg/CO_2/m²/yr)	EPC Rating
Scenario 1	149.01	5.4	27.95	152.63	334.99	-0.04%	80.2	0%	64C
Scenario 2	150.18	5.4	23.75	152.63	331.97	0.87%	78.3	2.37%	62C
Scenario 3	138.9	5.4	18.42	152.63	315.36	5.83%	73.3	8.6%	58C
Scenario 4	139.5	5.4	17.88	152.63	315.41	5.81%	73.1	8.85%	58C
Scenario 5	153.07	5.4	23.44	152.63	334.56	0.09%	78.7	1.87%	63C
Scenario 6	154.9	5.4	19.8	152.63	332.74	0.64%	77.2	3.74%	61C
Scenario 7	140.33	5.4	17.2	152.63	315.56	5.77%	72.9	9.1%	58C

About the Authors

Jason Hewins, BSc, OCDEA Support Team, Elmhurst Energy

Jason graduated from Coventry University in 2007 with BSc in Geography. Jason then started working for Elmhurst Energy in March 2008 and completed training and accreditation in various strands of assessment including On Construction Domestic Energy and more importantly Non Domestic Level 3 and Level 4 energy assessments. Since accreditation Jason has completed numerous non domestic surveys on both existing and new build non domestic buildings. Jason was heavily involved in completing a similar report to this one in 2011 which examined the impact of various retrofit options on four non domestic buildings as part of the early development of the Green Deal Scheme. Finally Jason was also involved in creating and presenting a CPD course to non domestic assessors briefing them on the changes to Part L2 of the building regulations this year.

Elmhurst Energy – Company Profile

Elmhurst Energy Systems Ltd has provided innovative solutions for the energy calculations of buildings since 1993 – we are at the forefront of this rapidly evolving energy assessment profession.

Founded in 1993, Elmhurst Energy Systems Ltd has always been a leading energy rating organisation. In the early stages we developed some of the first energy performance measurement software using the Governments Standard Assessment Procedure (SAP) methodology. The Elmhurst Streamline SAP software was launched and widely used amongst: mortgage banks, building societies, social landlords and other forward-looking environmentally conscious organisations.

Our systems are in use throughout the surveying and construction industries as well as Building Control bodies. Our systems comprise energy rating software, training and an Accreditation scheme (licensing) that supports Energy Assessors who wish to practice in the energy rating market for both, domestic properties and commercial buildings. We also provide a UK based Technical Support Team that ensures the quality and effectiveness of the overall product.

As a Government approved energy rating provider and the largest overall accreditor and trainer of Energy Assessors to date, our systems have driven the development of an entire industry and the creation of more than 4000 individual SMEs (small to medium size enterprises) who can provide Energy Performance Certificates (EPCs), Display Energy Certificates (DECs) and energy calculations throughout the UK.

Elmhurst Energy Services Ltd has been created as a separate sister company to Elmhurst Energy Systems Ltd. We focus on the provision of specialist energy rating consultancy direct to the construction industry throughout the UK.

National Association of Rooflight Manufacturers – Company Profile

The National Association of Rooflight Manufacturers (NARM) represents a complete cross section of the rooflight design and material type manufacturers in the UK. This includes: in-plane profiled rooflights, continuous barrel vaults, modular domes and pyramids, panel glazing systems and architectural glazing systems.

The association was formed to :-

- Highlight the benefits of daylight into the built environment.
- Promote co-operation between member companies, in order to develop and maintain rooflighting standards and codes of practice.
- Provide authoritative and objective information for rooflight specifiers.
- Provide an interactive web site where technical information is readily available and downloaded free of charge.

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