January 1992

BEST PRACTICE PROGRAMME

General Information Leaflet 4

ENERGY EFFICIENCY IN SCHOOLS

Opportunities for Saving Energy in Schools

Rationalisation of existing school stock as a result of falling rolls, and the need to replace or repair building fabric and services, provide ideal opportunities to introduce energy-saving measures and so reduce the national energy bill for schools, currently in excess of £450 million per year.

Introduction

Total energy consumption for all schools is in the region of 25,000 million kWh per year at an annual cost of over £450 million.

Opportunities to reduce this huge bill by energy-saving measures exist in both new and existing school buildings, but with school rolls falling in most parts of the country, relatively few new schools are being built. For example, in the financial year 1985/86 only 27 per cent of the total expenditure of £263 million for school building was directed at new building projects, whereas 73 per cent (£192 million), was directed at refurbishment, extensions and plant replacement.[1]

Types of school

Rationalisation of existing school stock, plus the need to renew or repair fabric and services, mean that refurbishment, extensions, alterations and maintenance provide excellent opportunities to install energy-saving measures and techniques. The scope and type of measures which are appropriate will depend to a large degree on the type of building as well as on the extent of refurbishment or maintenance work to be carried out. From an energy efficiency viewpoint, school building may be classified as either:

Thermally lightweight (fast thermal response)

System-built in the 1960s and early 1970s, characterised by flat roofs and large areas of glazing; generally single-storey primary schools or larger multi-storey secondary schools, or:

Thermally heavyweight (slow thermal response)

Solid brick or stone walled, typically Victorian or Edwardian; solid or cavity brick or brick/block walled, built between the wars or since the 1970s.

Different types of school building fabric offer different opportunities for energy saving; above: Hither Green School in South East London; overleaf: Marlborough School, St. Albans

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF ENERGY

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Marlborough School, St. Albans

Upgrading lightweight schools

The low thermal capacity of these buildings and large areas of glazing give rise to:

- rapid heat loss by conduction to the outside of the building
- overheating by solar radiation in south-facing rooms
- discomfort due to down draughts, i.e. convection currents at internal glazed surfaces

The aim is to reduce energy consumption for space heating and avoid overheating in summer without the need for excessive use of artificial lighting. Three fabric measures are indicated:

- insulating existing infill panels or replacing them with new insulated panels
- reducing glazed area, replacing existing glass with double-glazed units using low-emissivity glass, and/or providing shading by means of external blinds
- insulating flat roots by converting existing cold roofs into warm roofs or inverted roofs.

Insulating walls and roofs

These days many insulating materials are available. Some are inorganic in nature, such as glass fibre, foamed glass and mineral wool, whilst others are organic polymers such as phenolic resins, polystyrene, polyurethane and polyisocyanurate. Most are available either in block form or laminated with timber, metals or masonry materials. In addition, polyurethane and polyisocyanurate foams can be applied to wall panels and roof surfaces *in-situ*. All of these insulants have low values of thermal conductivity, commonly as low as 0.025W/mK, giving U-values of 0.3W/m^{2}K or better for roofs, depending on their design and the quality of workmanship.

Roof construction

Most flat roofs over a decade old are of the 'cold' type of construction where insulation, if present at all, is placed under the roof deck. This means that the decking is subjected to high thermal stress unless movement is accommodated adequately. In upgrading the thermal performance of a flat roof, it is therefore sensible to minimise this thermal movement and/or thermal stress in the decking by placing the insulation above it. Also, this is generally easier than placing insulation under the deck where access may be difficult.

Two methods of construction are available:

- the 'warm' roof where insulation is placed above the deck and then covered with a weather-proof skin, or
- the 'inverted' roof where the weather-proof skin is applied to the deck and this is topped with insulation; in this case it is generally necessary to protect the insulation with a heavy covering.

In both cases, it is important to protect the insulating material from interstitial condensation by applying a vapour check to the warm side of the insulation. In addition, it is essential to ensure that the structure is capable of accepting the increased load, especially in the case of the inverted roof.

Glazing

In order to improve the U-value of a walling element in a lightweight school, the area of glazing may be reduced. This would also reduce unwanted solar gain in south-facing rooms but, on the other hand, would reduce natural daylighting in the school, and therefore increase the use of electricity for artificial lighting. Furthermore, the replacement or radical alteration of complete facades is expensive.

Serious consideration should therefore be given to insulating existing infill panels and retaining the same area of fenestration, but replacing the existing glazing by double-glazed units with an internal pane of low-emissivity glass. This would retain the pleasant light environment for the children and also eliminate the need to increase artificial lighting. Such glass is transparent to the shorter wave heat from the sun but opaque to the longer wave heat re-radiated from the interior of the building. Thus heat is trapped by the glass. U-values of around 2.0 W/m^{2}K are thereby claimed for the glazing unit alone. In order to eliminate excessive solar gain, however, the outer pane of the double-glazed unit may be of 'solar control' glass; alternatively, adjustable shading can be provided.

Whether the economics favours this approach or that of reducing glazed areas, either by rebuilding the entire facade or by modifying it (eg by over-cladding or 'enveloping') will depend on a number of factors, not least the condition of the original wall panels. A novel approach to fabric modification, involving a reduction in the glazed area together with shading, has been demonstrated recently by Hampshire County Council and has shown significant benefits.[2]

Services

As is the case with all other buildings, lightweight schools should have services appropriate to the desired function of the building. Boilers should not be oversized, whilst control systems should meet the needs of the occupants and be compatible with the building fabric.

If the area of glazing is reduced, there will almost certainly be an increase in lighting load. In such circumstances, the economics of re-lamping with modern low-energy fluorescent units and, where appropriate, the provision of a lighting control system should be examined.

ENERGY EFFICIENCY IN SCHOOLS
OPPORTUNITIES FOR SAVING ENERGY IN SCHOOLS

Hither Green School: Boiler House. Insulation of pipework should include flanges

Improving the performance of older schools

Hither Green School in south east London was the subject of an Energy Efficiency Office Demonstration Project.[3] The school was built of solid brick walls and slate pitched roof in 1885 and was extended in 1914. Apart from the replacement of incandescent lamps by fluorescent units during rewiring in 1978/79 and a switch from oil to gas in 1981/82, no measures to reduce energy consumption or energy cost had been carried out.

Detailed measurements of temperature and air-change rates throughout the school showed a large temperature difference between the three floors of the school, on average 4.2°C between top and bottom floors, large air-change rates for the school as a whole and great variability between classrooms.

These results were due to:

- heat escaping through the uninsulated roof and dormer windows
- heat leaking into the ground floor from uninsulated underfloor pipes carrying water for central heating
- sash windows which, although in good condition, were excessively leaky
- poorly fitting external doors and worn thresholds.

In addition, boiler efficiency was found to be rather low at around 67–71 per cent due to the poor condition of the casing insulation.

Finally, measurements of electrical consumption and a study of lighting patterns in classrooms suggested that reduced consumption could be effected by the use of lighting controls.

The installed package

- in order to reduce temperature differences between floors, an insulation package for the roof and underground pipework was installed. In addition, the thermostat was removed from its former position on the top floor to the middle floor. Consequently the average difference in temperature between the top and bottom floors dropped from 4.2°C to 0.8°C
- air leakage through classroom windows was reduced by draughtstripping with a nylon brush product, whereas air leakage through external doors was reduced by replacing the old push-bar doors with well-fitting lockable doors, fitting draughtstripping and door closers and building up screeds and thresholds
- boiler efficiency was increased to about 75 per cent for the heating season by renewing boiler insulation and by insulating associated pipwork and flanges
- electrical consumption was reduced by fitting time switches to classroom lighting, and by a reduced load on the boilerhouse pumps effected by other improvements.

Top Floor Corridor *Top Floor Hall*

Examples of where an insulated suspended ceiling is, and is not, appropriate. The top floor corridor at Hither Green School is the former, while the top floor hall is the latter

Summary of results from Hither Green School

Measure	Capital Cost (£)	Annual Savings (£)	Packback Period (years)
Boiler Insulation	489	380	1.3
Pipework Insulation	1541	353	4.4
Loft Insulation	28268	2744	10.3
Thermostat Adjustment and Relocation	0	395	0.0
Draughtstripping	6703	566	11.8
Lighting Controls	2482	ca 250	ca 10.0

A summary of the results is shown in the Table. Some of the paybacks are rather long but these should be appropriate for a long-life public building. Energy savings of about 50 per cent were achieved. In addition, comfort conditions have been improved and the useful life of the building has probably been extended.

It is worth mentioning that part of the roof insulation to a vaulted ceiling, with dormer windows set in the roof, entailed a labour intensive method involving the layering of glass fibre blanket between battens and subsequent plasterwork and decoration. More recently, laminates of mineral wool and plasterboard with suitably low k values and acceptable fire properties have become available. The use of these in a similar situation would almost certainly involve a lower capital cost than that incurred at Hither Green.

It is not suggested that the package of measures installed at Hither Green is of universal application in buildings of this type, but a similar type of approach should be possible.

One technique to reduce energy consumption, used in the corridor areas of Hither Green School, is to install an insulated suspended ceiling. This can be a cost-effective means of thermally upgrading many older school buildings, provided that air quality can be maintained without the need to open windows in winter, too much window area is not sacrificed in favour of artificial lighting, and the amenity value and aesthetic character of the building are not diminished.

References

1 The Refurbishment Potential in School Buildings: ETSU Market Study No. 4; Energy Publications (CIRS), Newmarket, 1985

2 Architects' Journal, 9 March 1988, pp37-57

3 Energy-Efficient Refurbishment of a Victorian Primary School; BRECSU/EEO Report ED/254/119; Jan 1990

The Building Research Energy Conservation Support Unit

(BRECSU) at the Building Research Establishment, manages the EEO Best Practice programme for improving energy efficiency in buildings. BRECSU is currently collaborating with the Department of Education and Science, to prepare further guidance material on energy efficiency in schools.
These include:

Good Practice Guides

Good Housekeeping for Schools – A Guide for school staff, governors and pupils. GPG 29

Managing Energy in Schools – A Guide for Headteachers and Governors. GPG 39

Energy Efficiency in Schools – A Guide for Local Authority Chief Officers and Finance Officers. GPG 41

Energy Consumption Guides

Saving Energy in Schools –
The Headteacher's and Governor's Guide to Energy Efficiency. ECON 15

Saving Energy in Schools – The 'School Energy Manager's' Guide to Energy Efficiency. ECON 16

Saving Energy in Schools – The Local Authority Chief Officer's Guide to Energy Efficiency. ECON 17

Information Leaflets

Energy Efficiency in Schools and Colleges: Experiences in 20 Case Studies. IL22

For further information
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Further information on this or other building-related projects, please contact: Enquiries Bureau, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Garston, Watford WD2 7JR. Tel No: 0923 664258. Fax No: 0923 664097.

For further information on industrial projects, please contact the Energy Efficiency Enquiries Bureau, Energy Technology Support Unit (ETSU), Building 156, Harwell Laboratory, Oxon OX11 0RA. Tel No: 0235 436747. Telex No: 83135. Fax No: 0235 432923.

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