I.E.A. INTERNATIONAL ENERGY AGENCY

ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

# FINAL REPORT

## PART TWO: APPENDIX

Torino, March 1991

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I.E.A. INTERNATIONAL ENERGY AGENCY

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# APPENDIX

The following documents ore included in this Appendix:

Report on "Case Studies" of retrofits performed in U.K. and in Italy in school buildings and systems

Reports on six Seminars on special topics concerning school, held in U.K. and in Italy

# CASE STUDIES

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

### *"CASE STUDIES"*

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For a better understanding of the situation existing in U.K. and Italy, related to the work done or in progress concerning energy saving measures in the school field, the Working Group of Annex XV decided to conduct a survey on "Case Studies" of retrofits performed in both countries in school buildings and systems.

The intent of this survey was to acquire more information on energy saving measures which can be taken in school buildings and systems, their technical and economical potential, costs, payback time, etc.

The survey has been made in June-July 1989, with a detailed analysis of data on 44 "Case Studies", collected in U.K. and Italy, by means of forms specially prepared for this action of Annex XV.

Only essential data has been reported in the forms: country, name and address of the school involved, short description of the existing system, type and main charecteristic of the measure, indication of the results, and evaluation of the savings obtained.

As far as possible, every form deals with only one measure, in order to point out the results of the single measure, when more then one had been taken in the same school building.

In any case, retrofit measures concerning "building" are separated by measures concerning "systems".

For every measure the savings obtained are given in different ways, according to the input received: sometimes savings are given as a percentage of previous annual energy consumption, sometimes as amount of fuel saved; sometimes indication of the paybach time is also given.

All 44 forms are annexed to this report.

All retrofit measures considered have been divided in nine major items, as follows:

1- substitution and repair of window frames, application of double glazing;
2- insulation of roofs, walls, basements, false ceilings, etc.;
3- installation of control systems, monitoring systems, radiator thermostat valves;
4- improving of existing boilers, substitution with new boilers;
5- insulation of pipes, tanks, etc.;
6- separation of high temperature systems for space heating and low temperature systems for D.H.W. production; zone heating;
7- use of heat pump;
8- use of solar collectors;
9- lighting improvement.

Items 1 al 2 refer to actions made on buildings, while other seven items refer to actions made on systems and their components (mechanical, electrical, swimming pools, etc.).

A conclusive table has been compiled, reporting how many times the nine energy saving measures have been used in the 41 cases considered. if such cases may be regarded as a representative sample, we may have an idea of relative incidence and importance of the single measure.

Indications coming from this survery are in good accordance with data collected during seminars organized in the framework of ANNEX XV.

The results of this preliminary analysis are below briefly summarized.

| | number of retrofit measures |
|---|---|
| 3- Control Systems, Monitoring Systems, Radiator Thermostat Valves | 21 |
| 1- Substitution and Repair of Window Frames, with Double Glazing | 12 |
| 2- Insulationg of Roofs, Walls, Basements, False Ceilings | 10 |
| 4- Improving of Existing Boilers, Substitution with New Boilers | 7 |
| 8- Use of Solar Collectors | 4 |
| 6- Separation of High Temperature Systems for Space Heating from Low Temperature Systems for D.H.W. Production, zone heating | 4 |
| 9- Lighting Improvement | 3 |
| 7- Use of Heat Pump | 1 |
| 5- Insulation of Pipes, Tanks, etc. | 1 |

We can see that most popular energy conservation measures are concerning the building and related components: the majority of actions are directed to the heating systems, neglecting almost completely the electrical system: this result can be considered an indication.

The number of Case Studies on insulation of pipes and tanks is low, because this work is normally carried out routinally during installation and maintenance, as it is well known that insulation of hot pipes and tanks is one of the most cost effective energy conservation measure.

The Case Studies represent a cross section of Energy Efficiency measures that can be taken. They are not exhaustive in scope and application.

Authorities must evaluate proposed measures on economic and other merits.

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | COUNTRY: England<br>SCHOOL: Vandyke Upper School<br>MEASURE: Point of Use Hot Water Facilities | | | | | | X | | | | Payback: 2 years |
| 2 | COUNTRY: England<br>SCHOOL: Lady Bay Infants<br>MEASURE: Addition of an Insulated Suspended Ceiling to a Victoria Schools | | X | | | | | | | | -15-25% reduction in energy<br>-Reduced fabric maintenance costs<br>-Improved environmental conditions including lighting and acoustics |
| 3 | COUNTRY: England<br>SCHOOL: Alderman Pounder Infants, Nottinghamshire<br>MEASURE: External Insulation to a Flat Roof | | X | | | | | | | | -15-25% reduction in energy |
| 4 | COUNTRY: England<br>SCHOOL: Bradworthy Primary School, Devon<br>MEASURE: Use of Heat Pumps in a Ruad School | | | | | | | X | | | -21% energy cost saving, compared with oil at 1984 prices |
| 5 | COUNTRY: England<br>SCHOOL: Haywood Comprehensive, Gloucestershire<br>MEASURE: Swimming Pool. Automatic Ventilation Controls | | | X | | | | | | | -22% energy reduction<br>-2 years payback |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | COUNTRY: England<br>SCHOOL: Orchard House Primary, Cheshire<br>MEASURE: Overoofing a Flat Roof with Insulation and Metal Decking | | X | | | | | | | | - 35% reduction in energy consumption |
| 7 | COUNTRY: England<br>SCHOOL: Wigton Schools Swimming Pool, Cumbria<br>MEASURE: New Boilers and Flat Plate Heat Recovery, Permit Additional Mechanical Ventilation without Additional Energy Consumption | | | | X | | | | | | - mechanical ventilation added without increased heat loss |
| 8 | COUNTRY: England<br>SCHOOL: Queen Edith's Junior & Infants, Cambridgeshire<br>MEASURE: Replacement Boiler, heat emitters and Provision of Energy Controls | | | X | X | | | | | | - 40% energy reduction |
| 9 | COUNTRY: England<br>SCHOOL: Beacon Heath First Schools, Devon<br>MEASURE: Automatic Lighting Control | | | | | | | | | X | - 70% reduction in ligh-ting usage |
| 10 | COUNTRY: England<br>SCHOOL: Upcroft Junior, Berkshire<br>MEASURE: Removal of Electric Water Heating, Boiler Rearrangement and Provision of on Energy Management System | | | X | X | | | | | | - 30% energy reduction |

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| 8 | COUNTRY: England<br>SCHOOL: Queen Edith's Junior & Infants, Cambridgeshire<br>MEASURE: Replacement Boiler, heat emitters and Provision of Energy Controls | | | X | X | | | | | | - 40% energy reduction |
| 9 | COUNTRY: England<br>SCHOOL: Beacon Heath First Schools, Devon<br>MEASURE: Automatic Lighting Control | | | | | | | | | X | - 70% reduction in ligh-ting usage |
| 10 | COUNTRY: England<br>SCHOOL: Upcroft Junior, Berkshire<br>MEASURE: Removal of Electric Water Heating, Boiler Rearrangement and Provision of on Energy Management System | | | X | X | | | | | | - 30% energy reduction |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | COUNTRY: England<br>SCHOOL: Rosslyn Infant School, Nottinghamshire<br>MEASURE: Optimiser Control of Coal Fired Heating System | | | X | | | | | | | - Up to 40% saving in energy consumption<br>- payback: 2-3 years |
| 12 | COUNTRY: England<br>SCHOOL: Cornforth County High, Lancashire<br>MEASURE: Swimming Pool, Ventilation Control, Lighting Refurbishment and Cavity Insulation | X | | X | | | | | | X | - 25% energy reduction<br>- improved lighting levels |
| 13 | COUNTRY: England<br>SCHOOL: Litcham County Primary, Norfolk<br>MEASURE: Replacement External Walls and Glazing | X | | | | | | | | | - 25% reduction in energy consumption |
| 14 | COUNTRY: England<br>SCHOOL: The Gilberd, Colchester<br>MEASURE: Energy Management System in Multi Plant Room Installation | | | X | | | | | | | - Energy savings: 24,054 therms<br>- Payback: 2 years |
| 15 | COUNTRY: England<br>SCHOOL: Sunmers County Primary, Harlow<br>MEASURE: Energy Management System in Shared-Use Environment | | | X | | | | | | | - Savings:3.300 £/years<br>- Payback: 2,25 years |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | COUNTRY: England<br>SCHOOL: Tendring High School, Thorpe le Soken<br>MEASURE: Energy Management System | | | X | | | | | | | -35% reduction in energy consumption<br>-payback: 4.2 years |
| 17 | COUNTRY: England<br>SCHOOL: Thorpe Bay County High, Southend on SEA<br>MEASURE: Complete remdelling | X | | | | | X | | | | -30% reduction in energy consumption per $m^2$ floor are<br>-30% reduction in energy consumption per pupil |
| 18 | COUNTRY: England<br>SCHOOL: Notley High School, Braintree<br>MEASURE: Glazing Insulation | X | | | | | | | | | - savings: 3,454 £/year<br>- payback: 4.3 years |
| 19 | COUNTRY: England<br>SCHOOL: Nazeing County Primary<br>MEASURE: Thermosyphoning air panels incorporated into a refurbishment programme | | | | | | | | X | | - payback based on actual installed costs: 23.6 years |
| 20 | COUNTRY: England<br>SCHOOL: Burnt Mill Comprehensive, Harlow<br>MEASURE: Improved Heating Controls & Swimming Pool | X | | X | | | X | | | X | |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | COUNTRY: England<br>SCHOOL: Cecil Jones County High, Southend-on-Sea<br>MEASURE: Low Cost Measures | X | | X | | | | | | | - savings: 3,805 £/year<br>- Payback: 2.75 years |
| 22 | COUNTRY: Italy<br>SCHOOL: Elementary School "E. Filiberto" Vimercate (Milano)<br>MEASURE: "Heating plant improvement" | | | X | | | | | | | - 9.5% reduction in energy consumption |
| 23 | COUNTRY: Italy<br>SCHOOL: Elementary School "E. Filiberto" Vimercate (Milano)<br>MEASURE: "Building Insulation Improvement" | X | X | | | | | | | | - 16.7% reduction in energy consumption |
| 24 | COUNTRY: Italy<br>SCHOOL: Secondary School "A. Manzoni" Vimercate (Milano)<br>MEASURE: "Heating Plant Improvement" | | | X | X | X | | | | | - 17.3% reduction in energy consumption |
| 25 | COUNTRY: Italy<br>SCHOOL: Secondary School "A. Manzoni" Vimercate (Milano)<br>MEASURE: "Building Insulation Improvement" | | X | | | | | | | | - 13.7% reduction in energy consumption |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | COUNTRY: Italy<br>SCHOOL: Nursery School "Nord-Est" Vimercate (Milano)<br>MEASURE: "Heating Plant Improvement" | | | X | X | | | | | | - 16.3% reduction in energy consumption |
| 27 | COUNTRY: Italy<br>SCHOOL: Nursery School "Nord-Est" Vimercate (Milano)<br>MEASURE: "Building Insulation Improvement" | X | | | | | | | | | - 4.8% reduction in energy consumption |
| 28 | COUNTRY: Italy<br>SCHOOL: Secondary School, Sumirago<br>MEASURE: Installation of a High Efficiency Boiler Installation of a BEMS | | | X | X | | | | | | - 19% reduction in energy consumption<br>- improved comfort conditions |
| 29 | COUNTRY: Italy<br>SCHOOL: Secondary School, Sumirago<br>MEASURE: Increased Envelope Insulation | X | X | | | | | | | | - 14% reduction in energy consumption<br>- improved comfort conditions |
| 30 | COUNTRY: Italy<br>SCHOOL: Nursery School, Piancogno<br>MEASURE: Solar Collector for DHW Production, Installation of a BEMS | | | X | | | | | X | | - 24% reduction in energy consumption |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | COUNTRY: Italy<br>SCHOOL: Nursery School, Piancogno<br>MEASURE: Basement Insulation | | X | | | | | | | | - 5% reduction in energy consumption |
| 32 | COUNTRY: Italy<br>SCHOOL: Secondary School, Casnigo<br>MEASURE: Reduction of Boiler Capacity and Installation of Two Gas Fired Modules | | | | X | | | | | | - 20% reduction in energy consumption |
| 33 | COUNTRY: Italy<br>SCHOOL: Secondary School, Casnigo<br>MEASURE: Reduction of Window Area, Double Glazing to all Windows, Increased Envelope Insulation | X | X | | | | | | | | -22% reduction in energy consumption |
| 34 | COUNTRY: Italy<br>SCHOOL: Elementary School, Lanzada<br>MEASURE: Solar Air Collectors Connected to a Ventilation System | | | | | | | | X | | -25-28% reduction in energy consumption<br>-improved comfort conditions |
| 35 | COUNTRY: Italy<br>SCHOOL: Elementary School, Lanzada<br>MEASURE: Increased Envelope Insulation, Double Glazing on North Side | X | X | | | | | | | | -15-16% reduction in energy consumption<br>-improved comfort conditions |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | COUNTRY: Italy<br>SCHOOL: Elementary School, Montorfano<br>MEASURE: Ventilation System with Solar Air Collectors | | | | | | | | X | | - 25% reduction in energy consumption<br>- Improved comfort conditions |
| 37 | COUNTRY: Italy<br>SCHOOL: Elementary School, Montorfano<br>MEASURE: Increased Envelope Insulation, Double Glazing of the Classroom Windows, | X | X | | | | | | | | - 5-6% reduction in energy consumption |
| 38 | COUNTRY: Italy<br>SCHOOL: Technical School "Sommeiller" + High School "G. Ferraris", Torino<br>MEASURE: Flue Damper Control, Boilers Sequency, Thermostatic Valves on Radiators | | | X | | | | | | | -2,7% reduction in energy consumption<br>-Payback: 6,7 years |
| 39 | COUNTRY: Italy<br>SCHOOL: Technical School Rivoli (Torino)<br>MEASURE: Optimisation system, Boilers Sequency, Radiator Thermostat Valves | | | X | | | | | | | - 3% reduction in energy consumption<br>- Payback: 6,5 years |
| 40 | COUNTRY: Italy<br>SCHOOL: Technical School "G. Grassi", Torino<br>MEASURE: Optimisation system, Boilers Sequency, Radiator Thermostat Valves, Flue Damper Control | | | X | | | | | | | - 2.6% reduction in energy consumption<br>- Payback: 10 years |

| NUMBER | TITLE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | SAVINGS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | COUNTRY: Italy<br>SCHOOL: Technical School "Barocchio" Grugliasco (Torino)<br>MEASURE: Optimisation system, Boilers Sequency, Radiator Thermostat Valves | | | X | | | | | | | - 3% reduction in energy consumption<br>- Payback: 10 years |
| 42 | COUNTRY: England<br>SCHOOL: The Priory School Hitchin, Hertfordshire<br>MEASURE: Maind signalling for zone control | | | X | | | | | | | - Payback: 6 months |
| 43 | COUNTRY: England<br>SCHOOL: Frankland School Hoddesdon, Hertfordshire<br>MEASURE: Replacement electronic room thermostats | | | X | | | | | | | - Payback: 6 months |
| 44 | COUNTRY: England<br>SCHOOL: Ashling School Berkhamsted, Hertfordshire<br>MEASURE: Change to local electric water heaters | | | | | | X | | | | - Hot water service improved without significant effect on running costs |
| | | | | | | | | | | | |

1

COUNTRY: England

SCHOOL: Vandyke Upper School

## TITLE /MEASURE:

Point of Use Hot Water Facilities.

## DESCRIPTION OF INSTALLATION:

This, 1100 place, traditionally constructed school was built in 1975.

The large central oil fired boiler plant serves both the heating and hot water requirement. During the summer holiday period this large plant was inefficiently operated to serve the occasional demands of hot water for cleaning purposes. Also the long pipe routes resulted in the time consuming and energy wasteful running off of stored water.

To acheive greater energy efficiency 5 3KW 15 litres capacity water heaters were installed to serve the cleaners sinks. The plumbing and electrical installation was minimal.

As a result of this measure the main heating and plant is closed down for the holiday period. Energy is saved and more time is available to service the main plant. Also the cleaners prefer the instant availability of hot water. Key switches are operated by the caretaker to prevent the use of the electric water heaters during term time when the main plant is in normal operation.

## SAVINGS:

11,771KWh was saved in the first six week holiday after the installation.

Pay back period 4 six week holiday periods ie; 24 weeks.

FURTHER INFORMATION FROM:

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COUNTRY: England

SCHOOL: Lady Bay Infants

## TITLE /MEASURE:

Addition of an Insulated Suspended Ceiling to a Victoria Schools.

## DESCRIPTION OF INSTALLATION:

This building had high ceilings which were difficult to maintain and were thought not to provide a suitable scale for young children. Energy consumption and environment conditions were monitored before and after the installation of the suspended ceiling. The suspended ceiling line was chosen to match the existing window and partition details, helping to make it unobstrusive from outside the building. The height varies between 3.1m and 3.5m which is in keeping with the scale of the rooms and to allow adequate daylight penitration.

In order to further improving lighting and ventilation, the ceiling is flared up in places at 45% to meet the window heads. This feature increased the cost but allowed for the provision of natural ventilation from the existing upper windows without the security risk from the use of the lower sash windows.

The new ceiling consist of acoustic tiles with 100mm mineral fibre insulation, giving an overall 'U' value of 0.31 $Wm^{-2}C^{-1}$. On sloping areas the insulation roll is pinned at the upper edge to convenient woodwork and allowed to drape against the tiles. The opportunity was taken to replace the original lighting system with fluorescent fittings. Ventilation is provided above the new ceiling to prevent condensation and air is thus able to circulate freely between rooms. A safety film applied to the glazing above the ceiling prevents any broken glass from falling on to the insulation.

After the ceiling was installed room temperatures were found to be 3-4°C above the desired level. It was calculated that the elimination of this excess temperature by the addition of a heating system controller would produce a further 20% energy saving giving a typical combined energy saving from ceiling installation and temperature regulation of 35-40%.

## SAVINGS:

1. 15-25% reduction in energy.
2. Reduced Fabric maintenance costs.
3. Improved environmental conditions, including lighting our acoustics.

FURTHER INFORMATION FROM:

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3

COUNTRY: England

SCHOOL: Alderman Pounder Infants, Nottinghamshire

**TITLE/MEASURE:**

External Insulation to a Flat Roof.

**DESCRIPTION OF INSTALLATION:**

This is a system built school completed in 1970. The existing roof was due to be upgraded owing to the risk of interstitial condensation. The existing limited insulation gave a calculated U-value of 0.55 w/m2 °C. The opportunity was taken during the refurbishment works to add a top layer of insulation to save energy and also contribute to the preventative maintenance of the roof.

The roof consisted of a galvanised corrugated steel deck, overlayed with a vapour barrier, 12mm of fibre-board, three layers of felt and (before the insulation was applied) bonded chippings. The ceiling comprised 12mm mineral fibre tiles and a glassfibre quilt about 40mm thick; there was no vapour barrier. For this project, polyurethane foam was selected. This was light in weight and suitable for application to an existing roof which had so far not suffered serious deterioration.

The insulation is easily applied from the outside of a building without disrupting the activities inside. In the case study the elastomeric waterproof coating was found to be not fully satisfactory with some uncured patches and pinholes. The alternative finishing layer of asphalt and chippings might, therefore, be preferred, although in this case the additional loading would need to be considered.

In view of the relatively high capital cost and long payback period, these measures if applied to an otherwise sound roof would not be considered economically viable in themselves. Where, as in this case, the roof is due for major repair, the cost of extra insulation would generally be more than met by energy savings over a short period.

**SAVINGS:**

15-20% reduction in Energy.

FURTHER INFORMATION FROM:

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4

COUNTRY: England

SCHOOL: Bradworthy Primary School, Devon

**TITLE/MEASURE:**
Use of Heat Pumps in a Rural School

**DESCRIPTION OF INSTALLATION:**
Rural schools away from gas mains often have a limited choice of fuel. This 1872 school has a total area of 453m2 of which 293m2 comprises an extension built in 1985. Accommodation is for 104 pupils.

The U-values are: Walls 0.5w/m2 °k (new) 1.5w/m2 °k (old) and Roofs 0.35 w/m2 °k.

The school has a low temperature hot water (LTHW) heating system. The system comprises two 15 kW air to water heat pumps and a water store. There are two heating zones: the new extension and the old building.

The new building has underfloor heating with flexible polypropolene pipes laid on insulation over the concrete slab. After testing, the pipes were covered with special screed. The underfloor heating is controlled by a compensator and radiators have thermostatic radiator valves. The old building is heated by fan convectors, on a constant temperature circuit. Domestic hot water is provided by electric heaters.

Under normal conditions the heat pumps run at night, to take advantage of the off peak tariff, and heat up the water in the water store. THe store is a 6.5m3 glass fibre tank, with 100mm of U-foam insulation on the outside. The heat pumps switch off when the store is fully charged. When the optimiser calls for heating in the morning, hot water is pumped from the store into the heating circuits. The store is sized to meet the heating requirements for a normal working day. If for some reason (eg colder weather) the store is discharged before the end of the day, then it is bypassed and the heat pumps come on and supply the heating circuits directly. The store has three 6 kW emergency electric immersion heaters built into it, so if the heat pumps fail to start, the store can be charged up by the immersion heaters at night.

**SAVINGS:**
No boiler house requirement. 21% energy cost saving compared with oil at 1984 prices.

FURTHER INFORMATION FROM:

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COUNTRY: England

SCHOOL: Haywood Comprehensive, Gloucestershire

**TITLE/MEASURE:**

Swimming pool. Automatic Ventilation Controls.

**DESCRIPTION OF INSTALLATION:**

The pool hall and engineering plant was in good order. All work was directed at saving energy. Automatic ventilation controls were able to be installed without the need to close the pool for a long period therefore revenue was not lost.

The fresh air supply to the pool hall is passed through a heater battery, into the hall through diffusers around the pool perimeter and extracted through vents situated over the pool and in the ceiling void. Separate control units were installed to control the supply and extract air. Temperature and humidity sensors in the extract ducts control both the hall temperature, by operating a mixing valve on the heater battery, and humidity by varying the extract fan speed. A manually operated run back timer controller gives 10-20 minutes of maximum ventilation if there is a sudden peak load or a need to remove fumes or odours.

**SAVINGS:**

22% Energy Reduction. 2 year pay back.

FURTHER INFORMATION FROM:

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6

COUNTRY: England

SCHOOL: Orchard House Primary, Cheshire

**TITLE/MEASURE:**

Overoofing a flat roof with insulation and metal decking.

**DESCRIPTION OF INSTALLATION:**

This is a single storey flat roof school covering 976m². The roof leaked and had deteriorated to such an extent that major repairs were necessary. Only minimal insulation had been provided above the suspended ceiling.

In considering options for renewing the roof covering, the need to reduce heat loss was considered. Tapered insulation could not be used due to the large areas.

The original chippings were removed and the roofing felt was covered with a polythene vapour barrier and 100mm of fibre glass insulation. A slightly sloping aluminimum roof was superimposed above the existing roof and the new insulation. Energy has been saved and maintenance greatly reduced.

**SAVINGS:**

35% Reduction in Energy Consumption.

FURTHER INFORMATION FROM: Mr M J Patel
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7

COUNTRY: England

SCHOOL: Wigton Schools Swimming Pool, Cumbria

**TITLE/MEASURE:**
New Boilers and flat plate heat recovery, permit additional mechanical ventilation without additional energy consumption.

**DESCRIPTION OF INSTALLATION:**

The swimming pool was constructed in the early 1900's, and is of sandstone walls under a tiled roof. High levels of humidity was seriously damaging the building fabric.

Mechanical ventilation was installed to reduce humidity and contain the damage to the wall fabric. The resulting high rate of air changes would have caused unacceptably high levels of heat loss. A flat plate heat recovery unit was installed and the aging oil boilers were replaced by efficient modular oil boilers.

The energy conservation methods employed have permitted forced air changes without an increase in energy consumption. Fabric damage has been contained and environmental conditions improved adding to the viability of the pool.

**SAVINGS:**

Mechanical ventilation added without increased heat loss.

FURTHER INFORMATION FROM:

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8

COUNTRY: England

SCHOOL: Queen Edith's Junior & Infants, Cambridgeshire

**TITLE/MEASURE:**

Replacement Boilers, Heat Emitters and Provision of Energy Controls.

**DESCRIPTION OF INSTALLATION:**

The school covers an area of 2892m2, is a cavity wall construction under a pitched roof. There is extensive glazing.

Three oil fired boilers served under floor heat emitters in the classrooms and hall. Radiators were provided in the corridors. There was no local zone controls resulting in the whole building being heated for periods of partial occupancy.

Optimising and zone controls were installed. The heating was replaced with fan convectors with local thermostats. Control cables were installed to connect the fan convectors to the energy controls. New high efficiency boilers were installed. Environmental conditions were improved.

**SAVINGS:**

40% Energy Reduction.

FURTHER INFORMATION FROM: Mr M J Patel
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9

COUNTRY: England

SCHOOL: Beacon Heath First School, Devon

**TITLE/MEASURE:**

Automatic Lighting Control.

**DESCRIPTION OF INSTALLATION:**

This is a two storey school under a flat rooof. There is extensive glazing allowing a high level of daylight penatration. The floor area is about 1800m2.

The existing electrical installation was 30 years old and in need of renewal. In conjunction with that work tungsten lamps were replaced with fluorescent tubes and an automatic lighting control system installed. The controls were left inoperable in two typical classrooms. Hour run meters showed that in comparison with the controlled classrooms running hours were reduced from 500hr to 140hr over a 2 year period. Automatic controls would not have been viable as a separate project. It needed to be combined with general rewiring of the electrical installation.

**SAVINGS:**

70% Reduction in Lighting Usage.

FURTHER INFORMATION FROM:

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10

COUNTRY: England

SCHOOL: Upcroft Junior, Berkshire

**TITLE/MEASURE:**

Removal of Electric Water Heating, Boiler Rearrangement and Provision of an Energy Management System.

**DESCRIPTION OF INSTALLATION:**

This is a flat roofed single storey school covering an area of 1000m2. It was built in 1974.

Space heating, by natural convectors, and domestic hot water was provided by 4, 565kw gas fired boilers. Hot water for the kitchen was provided by an 18kw immersion heater in a 680 litre storage tank.

The school was surveyed to find ways of saving energy. It was not possible to install cavity insulation.

The kitchen immersion heater was removed and an indirect heater was installed and served exclusively by one of the existing boilers, that was subsequently derated.

The simple time switch control was replaced with an Energy Management System.

**SAVINGS:**

30% Energy Reduction.

FURTHER INFORMATION FROM: Mr M J Patel
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11

COUNTRY: England

SCHOOL: Rosslyn Infants School, Nottinghamshire

**TITLE/MEASURE:**

Optimiser Control of Coal Fired Heating System.

**DESCRIPTION OF INSTALLATION:**

This school, built in 1930, of traditional brick construction with pitched roofs was chosen for the study of the optimiser/compensator control of a coal-fired heating system. This device is more generally applied to gas-fired plants which are easier to control. However, if proved successful, there would be wide scope for its use, where the school heating systems are coal fired.

For the purposes of this study, one classroom in the school was isolated from the heating system and heated by electric radiators and convectors. A computer was used to emulate the existing system, controlling the electric heaters via a triac circuit. A second identical classroom was used as a control to establish the warming and cooling time constants and power output characteristics of the solid fuel heating system. The electric heating enabled the interaction of the optimiser with the building to be studied in a realistic and reproducible way which was unaffected by the way in which the solid fuel boiler was operated.

The original gravity fed heating system had been previously converted to a pumped system. The stoking rate was originally under the manual control of a caretaker. After the installation of a controller the system would be operated at a fixed stoking rate throughout the day, regulation being achieved by on/off control of the underfeed stoker. Manual adjustment of the stoking rate would then only be necessary to cope with seasonal or fuel changes.

The savings achieved support the replication of the device in other schools with slow response coal-fired heating where there is no secondary heat control such as thermostatic radiator valves.

**SAVINGS:**

Up to 40%. Payback 2-3 years.

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12

COUNTRY: England

SCHOOL: Cornforth County High, Lancashire

**TITLE/MEASURE:**

Swimming Pool, Ventilation Control, Lighting Refurbishment and Cavity Insulation

**DESCRIPTION OF INSTALLATION:**

The pool hall was constructed of breeze block cavity walls with a pitched roof. Double glazing was fitted as standard to all windows.

Space, pool and domestic hot water heating was provided by three 94kw gas fired hot water boilers running continuously. The pool hall was continuously mechanically ventilated with 100% fresh air, which in turn was heated to the required temperature by a heater battery from the main boilers. Fans supplied fresh air through high level wall mounted grills. Four extract fans were mounted on the opposite wall.

The ventilation rate is now controlled by the hall humidity and temperature sensors, so that if the humidity is lower than 72.5% RH and temperature greater than 15 C the ventilation rate would be reduced. A manual override is available in the plant room to provide full ventilation at spectator events.

Deteriorated fluorecent lighting was replaced with corrosion resistant sodium fittings.

Mineral wool cavity insulation was installed from the outside.

**SAVINGS:**

25% Energy Reduction. Improved Lighting Levels.

FURTHER INFORMATION FROM:

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13

COUNTRY: England

SCHOOL: Litcham County Primary, Norfolk

**TITLE/MEASURE:**

Replacement External Walls and Glazing.

**DESCRIPTION OF INSTALLATION:**

The school was built in 1961 and has a floor area of 513m2. It is a flat roof single storey construction with cavity walls incorporating large glazed areas with low level timber in-fill panels. The walls were a continuous maintenance problem. Staff complained of inadequate levels of heating.

New insulated and curtain walls have been provided. Glazed areas have been reduced and where possible sections of the existing windows were re-used. The deteriorated timber in-fill panels have been eliminated.

A simple draught lobby was constructed to reduce the heat loss from the most frequently used door.

Standards of comfort have been greatly improved and maintenance problems with the curtain walling eliminated. No additions were made to the heating system.

**SAVINGS:**

25% Reduction in Energy Consumption.

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(14)

COUNTRY: ENGLAND

SCHOOL: THE GILBERD, COLCHESTER

## TITLE /MEASURE:

ENERGY MANAGEMENT SYSTEM IN MULTI PLANT ROOM INSTALLATION

## DESCRIPTION OF INSTALLATION:

The heating and HWS system installed at the above named school consists of six plant rooms with a total of 23 Hamworthy atmospheric gas fired boilers, 11 heating zones and 6 HWS systems.

It was recommended to replace all the heating and HWS controls with an ITL EMS at an installed cost of £20,000.

An ITL unit C/W modem was installed in the Caretakers office and wired to control all 6 plant rooms, ie optimising all heating zones, load sequencing boilers, time controlling HWS and modulating all control valves. This enables the caretaker to receive alarms in his office such as boiler high limit, pump trip and low or high space temps, plus having full control of the heating and HWS plant.

## SAVINGS:

| | | |
|---|---|---|
| Gas consumption 86/87 | 66,007 therms | £23,300 |
| Gas consumption 88/89 | 41,953 therms | £13,200 |
| Savings | 24,054 therms | £10,100 |

Payback 2 years

## FURTHER INFORMATION FROM:

D.M. Curtis
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15

COUNTRY: ENGLAND

SCHOOL: SUMNERS COUNTY PRIMARY, HARLOW

## TITLE /MEASURE:

ENERGY MANAGEMENT SYSTEM IN SHARED-USE ENVIRONMENT

## DESCRIPTION OF INSTALLATION:

The heating system consists of a single boiler house, with three atmospheric gas fired boilers serving HWS and three main heating zones - Junior, Infant and Family Centre.

1. Junior zone is constant temperature serving 5 AHV and a perimeter radiator circuit with TRVs, with north and south zone valves.

2. Infant zone is modulated temperature serving radiators.

3. Family Centre is constant temperature serving radiators with TRVs.

Fuel cost over the last 3 years averages at 18,000 therms per year, costing £7,164 at current prices.

The recommendations were to replace the boilerhouse controls and control panel with an ITL EMS at an installed cost of £7,500.

Work commenced in July 1988 with the installation of the ITL unit, fitted in the caretaker's office. This enables him to monitor temperatures, receive alarms and control the heating plant from his office. The control panel was replaced with an interface panel, and room thermostats and duct sensors were replaced with ITL detectors. The work was completed during week commencing 29.8.88.

## SAVINGS:

Fuel cost for the first year from 1.11.88 to 1.11.89 are 9,683 therms @ 39.8 = £3,854 with a year's saving of £3,300.

Payback will be in 2.25 years on the basis of the first year of operation.

FURTHER INFORMATION FROM:

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Chelmsford, CM1 1LB

COUNTRY: ENGLAND

SCHOOL: TENDRING HIGH SCHOOL, THORPE LE SOKEN

## TITLE /MEASURE:

ENERGY MANAGEMENT SYSTEM

## DESCRIPTION OF INSTALLATION:

During the 1987 boiler replacement programme at the above named school, additional zone valves were installed to make more economic use of the heating system by enabling the Youth Centre, Gym and School Hall to be heated independently for out of school use. This work was completed on 1st October 1987.

Work then commenced to install an Energy Management System to enable the school to make more efficient use of new and existing zones. Work was completed in April 1988.

The oil used prior to boiler replacement during the year ending March 1987 was 91,692 litres. After the installation of new boilers and zone valves, consumption during the year ending March 1988 was 82,293 litres, with a reduction of 9,399 litres per annum.

After the installation of the Energy Management System during year ending March 1989, consumption was 59,441 litres, a further reduction of 22,852 litres per annum.

## SAVINGS:

Total savings 32,251 litres oil per annum = 35% reduction

Payback = 4.2 years

FURTHER INFORMATION FROM:

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COUNTRY: ENGLAND

SCHOOL: THORPE BAY COUNTY HIGH, SOUTHEND ON SEA

## TITLE /MEASURE:

COMPLETE REMODELLING

## DESCRIPTION OF INSTALLATION:

Total remodelling following the amalgamation of two schools. Increased capacity from 600 to 900.

The whole complex has been linked with patent glazing, enabling speedy erection with the minimum of disturbance to the existing structure or passage of children. This approach provides variety both visually and environmentally, the glazed areas or streets as they became known are unheated but provide protection to both new and existing buildings. They also act as a unifying element to the whole plan. Enhanced with seating, planting and display areas, they provide a much needed focus and meeting place.

The original main LPHW heating distribution comprised a single pumped circuit serving the whole of the school, with the flow temperature being adjusted by the caretaker. Appropriate re-zoning by additional but separately controlled pumps provided two compensated circuits and six individual timed controlled zones. In this way, out of phase zone occupations could be met without full school heating, particularly relevant for sports hall/gymnasium activities.

Fan convectors were largely replaced (being at the end of their useful life) by radiators, together with the addition of thermostatic radiator valves.

## SAVINGS:

- a 30% reduction in energy consumption cost per m floor area
- a 34% reduction in energy consumption cost per pupil

## FURTHER INFORMATION FROM:

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18

COUNTRY: ENGLAND

SCHOOL: NOTLEY HIGH SCHOOL, BRAINTREE

## TITLE /MEASURE:

GLAZING INSULATION

## DESCRIPTION OF INSTALLATION:

A method has been designed of forming a thermally insulating panel over the external surface of a sheet of glass. This comprises locating an aluminium trim around the periphery of the glass and subsequently filling the trim with a thermally insulating material, laminated to steel sheet (ie "Plastisol").

The outer surface of the glass is carefully cleaned and a layer of waterproof adhesive is applied to that surface. A frame-like trim (aluminium extrusions), is fitted against the glass and is fixed to the frame. The top trim member is formed as an angle section to provide a drip, whilst the bottom trim member and side members are formed as channel sections. A sheet of laminated steel and of polystyrene foam of 50mm thickness is coated with waterproof adhesive on its back surface and is inserted into the trim so that it fills the frame formed by the trim members. The foam is pressed against the pane of glass and against the trim members and adheres thereto.

Besides providing thermal insulation, the panel provides other advantages:

- considerable reduction of overheating in summer.
- more efficient radiator use
- improved radiant temperatures
- enhanced external aesthetic appearance (unsightly radiators concealed)
- resistance to impact and vandalism

Total cost of measures £14,746

## SAVINGS:

| | |
|---|---|
| 4/83 - 12/83 | £ 13,144 |
| 4/84 - 12/84 | 11,210 |
| | £ 1,934 |
| Extrapolated for full year | £ 3,454 |
| Payback period 4.3 years | |

FURTHER INFORMATION FROM:

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COUNTRY: ENGLAND

SCHOOL: NAZEING COUNTY PRIMARY

## TITLE /MEASURE:

THERMOSYPHONING AIR PANELS INCORPORATED INTO A REFURBISHMENT PROGRAMME

## DESCRIPTION OF INSTALLATION:

101m² of thermosyphoning air panels (TAP) were retro-fitted to Nazeing County Primary School in Essex in September 1988. The TAP's were installed as part of a three year demonstration project for the CEC on behalf of Essex County Council. Detailed monitoring of all the classrooms and offices has already commenced and will continue until the end of 1990.

These units are designed to contribute to the space heating requirements during Autumn and Spring whilst providing a degree of ventilative cooling during the Summer months. Their high level of thermal insulation will also reduce significantly the heat losses through the fabric of the building to the same degree as the conventional cladding system.

A cladding collector was adopted because a full refurbishment programme was already being implemented. By taking advantage of the opportunity presented by refurbishment and incorporating the TAP's into a conventional curtain-wall cladding system, the over-cost of this passive solar feature was minimised. The manufacturers of the insulating panels were able to produce a TAP without compromising the performance of the conventional cladding units.

## SAVINGS:

The performance from each collector was estimated to be 500MJ/m²/annum which represents 14,000 kwh per annum for the 101m² of TAP's. Based on the actual installed costs and also the anticipated installed cost if the collectors were mass produced, the payback periods of this system are 23.6 and 14.7 years respectively.

## FURTHER INFORMATION FROM:

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**COUNTRY:** ENGLAND

**SCHOOL:** BURNT MILL COMPREHENSIVE, HARLOW

## TITLE /MEASURE:

IMPROVED HEATING CONTROLS & SWIMMING POOL

## DESCRIPTION OF INSTALLATION:

A highly glazed curtain walled construction, 4 storeys with swimming pool.

Actions

zoning
improved controls
extensive glazing insulation

Swimming pool

pool covers
high efficiency lighting
shower timers

## SAVINGS:

Not yet known

## FURTHER INFORMATION FROM:

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**COUNTRY:** ENGLAND

**SCHOOL:** CECIL JONES COUNTY HIGH, SOUTHEND-ON-SEA

## TITLE /MEASURE:

LOW COST MEASURES

## DESCRIPTION OF INSTALLATION:

| | |
|---|---|
| 4 zones instead of 2, optimised & compensated | £ 8000 |
| Draught lobbies & draught proofing | 860 |
| Secondary glazing on rooflights | 1250 |
| Single point water heaters | 150 |
| Door closers | 210 |
| Total cost of measures | £10,470 |

## SAVINGS:

| | | |
|---|---|---|
| Gas consumption 86/87 | 45,000 therms p.a. | £16,090 |
| Gas consumption 88/89 | 39,000 therms p.a. | £12,285 |
| | Savings | £ 3,805 |

Payback 2.75 years

**FURTHER INFORMATION FROM:**

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22

COUNTRY: Italy

SCHOOL: Elementary School Emanuele Filiberto - Vimercate, Milano

**TITLE /MEASURE:** "Heating plant improvements"

## DESCRIPTION OF INSTALLATION:

1) Installation of an integrated heat metering and control system, including:

- Radiator thermostat valves
- Boiler cascade (sequencing) control
- Heating start-stop optimizer
- Heat meters
- Monitoring and data storage system

**SAVINGS:** Calculated savings for retrofit actions:

1) Controls 9,5%

FURTHER INFORMATION FROM:

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23

COUNTRY: Italy

SCHOOL: Elementary School Emanuele Filiberto - Vimercate, Milano

## TITLE /MEASURE: Building insulation improvements

## DESCRIPTION OF INSTALLATION:

The following retrofitting actions were carried out.

1) Replacement of the existing window frames with new PVC frames and double glazing, in the classroom buildings
2) Sealing of the existing window frames in the gymnasium and dining room hall buildings
3) Insulation of:

   - Roof floor with a mineral wool layer 10 cm thick
   - Basement floor (over Cellars and accessible stone foundation) with 3 cm mineral wool layer
   - Underwindow behind radiators with aluminum foil coated polestyrene foamboard 10 cm thick
   - Rolling blinds box with mineral wool 2 cm thick
   - False ceiling on the gymnasium and dining hall with a 5 cm mineral wool layer.

Corridors in the schools building were lowered to the net height of 3 m with insulated false ceiling.

## SAVINGS:

Calculated savings for retrofit actions:

| | |
|---|---|
| 1) New windows | 6,0% |
| 2) Windows improv. | 1,0% |
| 3) Insulation | 9,7% |
| Total | 16,7% |

FURTHER INFORMATION FROM:

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24

COUNTRY: Italy

SCHOOL: Secondary School "A. Manzoni" - Vimercate, Milano

**TITLE /MEASURE:** "Heating plant improvement"

## DESCRIPTION OF INSTALLATION:

1) Improving of the existing boilers by

   - Replacement of the insulation with new and thicker one,
   - Addition of turbolators in fire tubes

2) Installation of an integrated heat metering and control system including:

   - Radiator thermostatic valves
   - Boilers cascade (sequencing) control
   - Heating start-stop optimizer
   - Heat meters
   - Monitoring und data, storage system

**SAVINGS:** Calculated saving for retrofit actions

| | |
|---|---|
| 1) Boilers | 3,5% |
| 2) Controls | 14,4% |
| Total | 17,9% |

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COUNTRY: Italy

SCHOOL: Secondary School "A. Manzoni" - Vimercate, Milano

**TITLE /MEASURE:** Building insulation improvement

**DESCRIPTION OF INSTALLATION:**

The following retrofitting actions were carried out.

1) Insulation of
   - External wall with expanded granular "pearlite" blowed in the existing cavity of the wall 6 cm thick, in the classroom and gymnasium building.
   - Roof floor with a glass wool layer 12 cm thick
   - Roof pitch with glass wool layer 6 cm thick
   - Terraces with rainproof expanded polistyrene 6 cm thick
   - Basement floor over cellars and arcade with expanded polistyrene 4 cm thick

The classroom corridor at 1st floor was lowered by means of a false ceiling insulated with a glass wool layer 6 cm thick.

**SAVINGS:** Calculated saving for retrofit actions
1) Insulation 13,7%

FURTHER INFORMATION FROM:
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COUNTRY: Italy

SCHOOL: Nursery School "Nord-Est" - Vimercate, Milano

**TITLE /MEASURE:** "Heating plant improvement"

## DESCRIPTION OF INSTALLATION:

The following retrofitting actions were carried out.

1) Replacement, of the existing boilers with two new high efficiency ( 90%) ones
2) Installation of an integrated heat metering and control system; including:
   - Radiator thermostatic valves
   - Heating start-stop optimizer
   - Heat meters
   - Monitoring system

## SAVINGS:

Calculated saving for retrofit actions:

| | |
|---|---|
| - Boilers | 6,7 % |
| - Controls | 9,6 % |
| Total | 16,3 % |

FURTHER INFORMATION FROM:

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27

COUNTRY: Italy

SCHOOL: Nursery School "Nord-Est" - Vimercate, Milano

**TITLE /MEASURE:** Building insulation improvement

## DESCRIPTION OF INSTALLATION:

The following retrofitting actions were carried out.

1) Replacement, in the existing frame, of the original single glazing with new double glazing (4/6/4 mm); the percentage of trasparent versus opaque surface is 52%.

**SAVINGS:** Calculated saving for retrofit actions:
- Double glazing 4,8%

FURTHER INFORMATION FROM:

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COUNTRY: Italy

SCHOOL: Sumirago Secondary School

**TITLE /MEASURE:** - Installation of a high efficiency Boiler
- Installation of a BEMS

## DESCRIPTION OF INSTALLATION:

The Sumirago Secondary School is located on a hill site near Varese.

The structure of the building is prefabbricated with traditional partitions in hollow pot bricks. The flat roof, with no insulation, is built with prestressed beams.

The major retrofit measures on the heating systems of the School were the following:

- the boiler has been changed with a new higher performance unit.
- the control system has been provided by a BEMS and redesigned in order to compensate for the solar gains through the south facade.

The physical parameters of the building are: volume: 3.283 $m^3$; floor area 900 $m^2$.

**SAVINGS:** - 19% reduction in energy consumption
- Improved comfort conditions

FURTHER INFORMATION FROM:

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29

COUNTRY: Italy

SCHOOL: Sumirago Secondary School

## TITLE /MEASURE: Increased Envelope Insulation

## DESCRIPTION OF INSTALLATION:

The Sumirago Secondary School is located on a hill site near Varese.

The structure of the building is prefabbricated with traditional partitions in hollow pot bricks. The flat roof, with no insulation, is built with prestressed beams.

The major retrofit measures on the building were:

- new windows on north side, reducing the window area and installing double glazing;
- added insulation on the roof: 10 cm of two component insulation has been sprinkled: ultraviolet protection has also been provided.

The physical parameters of the building are:
volume: 3.283 $m^3$; floor area 900 $m^2$; glazing area before: 267 $m^2$; glazing area after: 216 $m^2$.

Moreover a drainage system has been provided all around the school in order to prevent the flooding of the plant room during rainy days.

## SAVINGS:

- Reduction in energy consumption: 14%
- Improved comfort conditions

FURTHER INFORMATION FROM:

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30

COUNTRY: Italy

SCHOOL: Piancogno Nursery School

**TITLE /MEASURE:** - Solar collector for DHW production
- Installation of a BEMS

## DESCRIPTION OF INSTALLATION:

The Piancogno Nursery School is located some 50 km north of BRESCIA in Camonica Valley.

The building, entirely prefabricated, is made with sandwich panels and the roof has prestressed beams, The overall level of insulation is good except for the basement situated over a crawal space, which is not insulated.

The major retrofit measures on school heating systems were: installation of a high efficiency solar collector system with evacuated tubes for hot water production to be used in the school kitchen and in the lavatories; a Building Energy Management System has been installed.

The physical parameters of the building are: volume 3.340 $m^3$; floor area 860 $m^2$; windows area 220 $m^2$.

**SAVINGS:** During 1983-1984 heating season a monitoring campaign has been launched and the results gave a 8% reduction in energy consumption due to BEMS installation.
An additional 16% in energy consumption was saved by using the solar collector system.

FURTHER INFORMATION FROM:

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31

COUNTRY: Italy

SCHOOL: Piancogno Nursery School

TITLE /MEASURE: Basement insulation

## DESCRIPTION OF INSTALLATION:

The Piancogno Nursery School is located some 50 km north of BRESCIA in Camonica Valley.

The building, entirely prefabricated, is made with sandwich panels and the roof has prestressed beams, The overall level of insulation is good except for the basement situated over a crawal space, which is not insulated.

The major retrofit measures on school heating systems were: installation on basement.

Moreover moveable alluminium louvers have been installed on south openings to prevent summer overheating.

The physical parameters of the building are: volume 3.340 $m^3$; floor area 860 $m^2$; windows area 220 $m^2$.

**SAVINGS:** During 1983-1984 heating season a monitoring campaign has been launched and the results gave a 5% reduction in energy consumption due to additional insulation

FURTHER INFORMATION FROM:

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COUNTRY: Italy

SCHOOL: Casnigo Secondary School

**TITLE /MEASURE:** Reduction of boiler capacity and installation of two gas fired modules

## DESCRIPTION OF INSTALLATION:

The Casnigo Secondary School is located 30 km North of BERGAMO. The building is made out of concrete bearing walls and perimeter walls in hollow pot bricks.

It is a three story building with a central hall and two classrooms wings. All classrooms face south; the envelope of the central hall and the end of classrooms wings is built with glass blocks, made with transparent glass and a concrete frame.

The retrofit measures concerning heating systems involved the rehabilitation of the whole building.

The oil-fired boiler was changed with two gas-fired modules, and the capacity was reduced to take into account the reduced load of the building. The energy consumption and the climatic conditions have been monitored during the 1983-1984 heating season.

**SAVINGS:** A 20% total energy reduction has been estimated for a typical year.

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33

COUNTRY: Italy

SCHOOL: Casnigo Secondary School

**TITLE /MEASURE:** - Reduction of window area - Double glazing to all window - Increased envelope insulation

## DESCRIPTION OF INSTALLATION:

The Casnigo Secondary School is located 30 km North of BERGAMO. The building is made out of concrete bearing walls and perimeter walls in hollow pot bricks.

It is a three story building with a central hall and two classrooms wings. All classrooms face south; the envelope of the central hall and the end of classrooms wings is built with blocks, made with transparent glass and a concrete frame.

The retrofit measures involved the rehabilitation of the whole building.

The size of the windows was reduced, and an overall internal insulation was added.

The ceiling and the basement were insulated too. The physical parameters are: volume 4.726 $m^3$; floor area 1.284 m ; glazing area before retrofit 345 $m^2$; glazing area after retrofit: 244 $m^2$ . The energy consumption and the climatic conditions have been monitored during the 1983-1984 heating season.

**SAVINGS:** A 22% total energy reduction has been estimated for a typical year.

FURTHER INFORMATION FROM:

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COUNTRY: Italy

SCHOOL: Lanzada Elementary School

**TITLE /MEASURE:** - Solar air collectors connected to a ventilation system

## DESCRIPTION OF INSTALLATION:

The Lanzada Elementary School is located 20 km north of the city of Sondrio in Regione Lombardia. It is at the end of val Malenco (a side valley of Valtellina), below the Bernina Range in the Alps. The microclimate is tipical of the high Alpine Belt: snowy winter and spring with sunny days and cool nights. Summers are modestely warm. The School is a masonry building made with massive stones with an internal layer of bricks (average thickness 70 cm). The school has a compact shape with all classroom facing south. It is a three story building with a small gymnasium at the lower level. In order to decrease energy comsumption, the following major retrofit measures on heating systems of the school were taken:

- installation of solar air collectors on south facade connected to a ventilation system

The physical parameters of the building are: volume 2.600 $m^3$; floor area 760 $m^2$; glazing 150 $m^2$. The solar Air Collectors Parameters are:

- surface area: 130 $m^2$ (n° 8 collectors 1,25x13)
- tilt: 20 degrees
- glazing: double (polycarbonate)
- orientation: south

The building has been monitored during 1985/1986 heating season. Two 12 day periods were analyzed (November and March). These two periods are representative of typical spring and fall climate.

**SAVINGS:**
- 25÷28% reduction in Energy consumption
- Improved comfort conditions due to the installation of a ventilation system

FURTHER INFORMATION FROM:
Ing. Sergio ZABOT
Energy Issue Dpt
Regione Lombardia
Via F. Filzi, 22
20100 MILANO
Tel. 02-67654907

COUNTRY: Italy

SCHOOL: Lanzada Elementary School

**TITLE /MEASURE:** - Increased envelope insulation
- double glazing on north side

## DESCRIPTION OF INSTALLATION:

The Lanzada Elementary School is located 20 km north of the city of Sondrio in Regione Lombardia. It is at the end of Val Malenco (a side valley of Valtellina), below the Bernina Range in the Alps. The microclimate is tipical of the high Alpine Belt: snowy winter and spring with sunny days and cool nights. Summers are modestely warm. The School is a masonry building made with massive stones with an internal layer of bricks (average thickness 70 cm). The school has a compact shape with all classroom facing south. It is a three story building with a small gymnasium at the lower level. In order to reduce energy comsumption, the following major retrofit measures on the building were taken:

- increased envelope insulation on north side
- double glazing of all windows on north side
- ceiling insulation

The physical parameters of the building are: volume 2.600 $m^3$; floor area 760 $m^2$; glazing 150 $m^2$. The building has been monitored during 1985/1986 heating season. Two 12 day periods were analyzed (November and March). These two periods are representative of typical spring and fall climate.

## SAVINGS:

- 15÷16% reduction in Energy consumption
- improved comfort conditions due to the installation of a ventilation system

FURTHER INFORMATION FROM:

Ing. Sergio ZABOT
Energy Issue Dpt
Regione Lombardia
Via F. Filzi, 22
20100 MILANO
Tel. 02-67654907

COUNTRY: Italy

SCHOOL: Montorfano Elementary School

**TITLE /MEASURE:** Ventilation system with solar collectors

## DESCRIPTION OF INSTALLATION:

The Montorfano Elementary School is located some 5 km south east of the city of Como. Its microlimate is quite different from the nearby lake Como region, being less mild. The School building is made with load-bearing concrete walls. The major retrofit measures on the heating systems of the school were: installation of a ventilation system fed by a solar air collector and a back-up system; reduced size of the boiler. The physical parameters of the building are: volume 3.570 $m^3$, floor area 1.105 $m^2$, glazing area 383 $m^2$. The solar air collector parameters are:

- surface area 42,5 $m^2$
- tilt: 70 degrees
- glazing: double (metacrilate)
- orientation: 15 degrees east of south

The heat balance for the building was evaluated for a 10 day period during March 1985, for the following parts of the school:

1: only the classrooms, since the solar air collectors serve these ambients

2: the entire building

The solar contribution in the classroom area gave a 28% value (20% passive; 8% active).

For the whole building the solar contribution dropped to 18% (15% passive and 3% active)

**SAVINGS:**
- 25% reduction in energy consumption
- Improved comfort conditions in the classrooms (before retrofit there was not enough ventilation in the classrooms)

FURTHER INFORMATION FROM:
Ing. Sergio ZABOT
Energy Issue Dpt
Regione Lombardia
Via F. Filzi, 22
20100 MILANO
Tel. 02-67654907

COUNTRY: Italy

SCHOOL: Montorfano Elementary School

**TITLE /MEASURE:** Increased envelope insulation. Double glazing of the classroom windows

## DESCRIPTION OF INSTALLATION:

The Montorfano Elementary School is located some 5 km south east of the city of Como. Its microlimate is quite different from the nearby lake Como region, being less mild.

The School building is made with load-bearing concrete walls.

Two classroom wings are built on a gently sloping hill side and are partly below ground level on the corridor side.

The section connecting the two wings is two story.

The ground floor has a caretaker's apartment and school offices.

The first floor contains the gymnasium.

The major retrofit measures on the building were: increased inside envelope insulation, double glazing of additional window frames on west side; thermal cut windows.

The physical parameters of the building are: volume 3.570 $m^3$, floor area 1.105 $m^2$, glazing area 383 $m^2$.

The building has been monitored during 1984-1985 heating season.

## SAVINGS:

5÷6% reduction in energy consumption

FURTHER INFORMATION FROM: Ing. Sergio ZABOT
Energy Issue Dpt
Regione Lombardia
Via F. Filzi, 22
20100 MILANO
Tel. 02-67654907

COUNTRY: Italy (TURIN)

SCHOOL: Technical School "Sommeiller" High school "G. Ferraris"

**TITLE /MEASURE:** Flue damper contros, boilers sequency thermostatic valves on radiators

## DESCRIPTION OF INSTALLATION:

This school has 88 classrooms with 1760 students, built in 1950-1955; it is a three- story building, with traditional structure, and large windows.

| | |
|---|---|
| total volume: | 78.102 $m^3$ |
| external surface: | 21.757 $m^2$ |

The heating system is hot water forced circulation type.

The central boiler house is equipped with three 930 kW steam boilers, producing hot water for the heating system, in the range of 80-70 °C, by means of heat exchangers.

Retrofitting measures adopted in this school have been the following:

- installation of a sequency automatic control for the three boilers, with a flue damper preventig cold air from flowing through the boiler, when the burner is not in operation;
- installation of thermostatic valves on about 40 radiators of the heating system in the East side of the building, in order to attain a better equilibrium of temperature distribution within the classrooms.

**SAVINGS:**
- 5.000 liters of oil was saved in one year after the improvent equal to 2,7% of the total oil requrement in a year.
- Pay-back period 6,7 years.

FURTHER INFORMATION FROM:
Prof. G. RUSCICA
Dipartimento di Energetica
Politecnic of Turin
C.so Duca degli Abruzzi, 24
10121 TORINO (Italy)

COUNTRY: Italy

SCHOOL: Rivoli Technical School (Turin)

**TITLE /MEASURE:** Optimization device, boilers sequency, thermostatic valves on radiators

## DESCRIPTION OF INSTALLATION:

The School has a very old building, with high ceilings and thick and heavy walls, wide windows; it has 102 classrooms with 2.040 students. Total volume is 82.000 $m^3$ divided in several blocks.

For the central heating system there is a large boiler house, with a total power of 6.9 MW, divided in three boilers: one unit is kept always in stand by, but the overall power of the boiler system is considered to be twice as much the heating requirements of the school.

Retrofitting measures adopted in the school have been the following:

- installation of an optimizer system for a better control of the internal temperature: the systems takes into account the partial or total building occupancy, the heat storedin the heavy walls and roof in start-up phase, and the actual indoor and autdoor conditions in the steady-state operation;
- installation of a sequency automatic control system for the three boilers of the central plant, for a better matching of the oil-fired boiler output to the buildings requirement, with improved efficiency;
- installation of thermostatic valves on about 20 radiators of the heating system in the East side of the building, in order to attain a better equilibrim of temperature distribution within the classrooms.

## SAVINGS:

- 6.000 liters of oil was saved in one year after the improvement, equal to 3% of the oil requrement in a year
- Pay-back period 6.5 years.

FURTHER INFORMATION FROM:

Prof. G. RUSCICA
Dipartimento di Energetica
Politecnic of Turin
C.so Duca degli Abruzzi, 24
10121 TORINO (Italy)

COUNTRY: Italy (Turin)

SCHOOL: Technical School "C. Grassi"

**TITLE /MEASURE:** Optmization device, boilers sequency, radiator thermostatic valves and flue dampers controls

## DESCRIPTION OF INSTALLATION:

This School has 54 classrooms for 1.100 students; built in 1965-1970; traditional structure and walls, with very large windows, single glazing.

The overall volume is 69.500 $m^3$, with an external surface of 23.400 $m^2$, divided in two blocks.

There is a conventional hot water forced circulation heating system, with three 1.050 kW hot water boilers.

One unit is constantly in stand-by.

The retrofitting measures have been the following:

- installation of optimization devices, one per each block, for a better control of the internal temperature;
- installation of a sequency automatic control for the operation of the three boilers, with a flue damper preventing cold air from flowing through the boilers when the burner is not in operation;
- installation of thermostatic valves on about 60 radiators of the heating system in the East side of the buildings in order to attain a better temperature distribution.

**SAVINGS:**

- 4.000 liters of oil was saved in one year after the improvement, equal to 2,6% of the toal oil requrement in a year
- Pay-back period 10 years.

FURTHER INFORMATION FROM:

Prof. G. RUSCICA
Dipartimento di Energetica
Politecnic of Turin
C.so Duca degli Abruzzi, 24
10121 TORINO (Italy)

41

COUNTRY: Italy

SCHOOL: Technical School "Barocchio" - Grugliasco (TURIN)

## TITLE /MEASURE: Radiator thermostatic valves

## DESCRIPTION OF INSTALLATION:

The school has 82 classrooms with 1.820 students; it is a modern construction built in 1975-1977, with prefabricated panels in reinforced concrete slabs with an insulating layer inside, divided in two blocks, two story each.

Total volume of the buildings is 148.710 $m^3$, with external surface of 73.800 $m^2$.

There is a boiler house for the central heating systems, equipped with 3 boilers producing high temperature pressure water, 3,5 MW each.

By means of heat exchangers hot water is produced, both for the heating system and D.H.W. system.

Retrofitting measures have been limited to installation of some 105 thermostatic valves on radiators, for a better equilibrium of the temperature of the classrooms.

## SAVINGS:

- 5.000 $m^3$ standard fuel gas was saved in one year after the improvement, equal to 3% of the energy requrment
- Pay-back period 10 years.

FURTHER INFORMATION FROM: Prof. G. RUSCICA
Dipartimento di Energetica
Politecnic of Turin
C.so Duca degli Abruzzi, 24
10121 TORINO (Italy)

42

COUNTRY: E N G L A N D

SCHOOL: THE PRIORY SCHOOL, HITCHIN, HERTFORDSHIRE

## TITLE /MEASURE: MAINS SIGNALLING FOR ZONE CONTROL

## DESCRIPTION OF INSTALLATION:

The heating in this large school is mainly provided by fan convectors served from a central boiler house. These convectors are grouped together into a number of zones, each controlled from a local panel.

It was impractical on such a large site for the operator of the plant to readily use the control panels to cut off heating in areas as they became unused at times during the day or night.

It was not cost effective to wire back from the remote panels to the boiler house, so in conjunction with a manufacturer, Hertfordshire County Council designed a signalling system which utilised existing electrical wiring. The central transmitter was sited in the boiler house and receivers were sited local to the existing remote control panels. The operator now has only to operate simple on/off switches centrally to control the heating in any zone. Because of the convenience of the system, a payback of only months was monitored. Similar systems have since been installed in many of the larger establishments of the Authority.

## SAVINGS:

Six Months

FURTHER INFORMATION FROM:

Rex Bowen
Chief Heating Engineer
County Architect's Department
County Hall
HERTFORD
E N G L A N D

43

COUNTRY: ENGLAND

SCHOOL: FRANKLAND SCHOOL, HODDESDON, HERTFORDSHIRE

## TITLE /MEASURE: REPLACEMENT ELECTRONIC ROOM THERMOSTATS

## DESCRIPTION OF INSTALLATION:

Many classrooms in the UK are heated by fan convectors served by low pressure hot water and controlled by wall mounted bi-metallic strip thermostats. Having a large differential of 3°C to 5°C, these thermostats need to be set at a higher setting than the required room temperature in order to offset the cold draught effect at the cut-in level. In addition, this type of thermostat is prone to tampering or, if a guard is fitted to combat this, the differential becomes exaggerated.

In conjunction with a leading electronics firm, Hertfordshire County Council designed a tamperproof electronic thermostat, with a concealed adjustable temperature setting and adjustable differential. When the new thermostats were fitted, because an accurate lower temperature setting was able to be made, considerable savings in fuel use were monitored. Note that the thermostats were all provided with an AUTO/OFF facility. The adjustable differential was found to be necessary to prevent a too frequent on/off cycle.

A better environment was provided and although the thermostats themselves cost three times as much as the standard thermostats, a 6 months payback period was obtained.

## SAVINGS:

Six Months Payback

FURTHER INFORMATION FROM:

Rex Bowen
Chief Heating Engineer
County Architect's Department
County Hall
HERTFORD
ENGLAND

COUNTRY: ENGLAND

SCHOOL: ASHLYNS SCHOOL, BERKHAMSTED, HERTFORDSHIRE

## TITLE /MEASURE: CHANGE TO LOCAL ELECTRIC WATER HEATERS

## DESCRIPTION OF INSTALLATION:

This 1930's brick building has a high area to pupil ratio with services distribution via large crawl-ways underneath the ground floor.

The antiquated and inefficient solid fuel system was replaced with high efficiency gas fired plant and the more recent extensions served from local boilers to overcome deficiencies in distribution.

The main improvement, however, was in the hot water supply. The original system required one of the large boilers to remain in operation merely to offset the distribution losses from the mains in the ducts.

It became necessary to remove the friable asbestos insulation from the ducted mains to conform to more stringent safety precautions, and it was obvious that if the HW distribution mains were not re-insulated, the capital saved would be more than sufficient to provide local electric water heaters in lieu of the centralised system.

183kW of point-of-use electric water heaters were installed with a central automated control to reduce the maximum demand.

Electric consumption remained similar, as the increased consumption expected from the HW heaters was offset by the scrapping of the School's supplementary electric space heaters which became unnecessary with the more efficient heating system.

Thus both the environmental conditions and the hot water supply were improved without a significant effect on running costs.

## SAVINGS:

Poor heating and hot water services improved to an acceptable level of performance and efficiency with only a nominal nett capital input and little variation in running cost.

FURTHER INFORMATION FROM:

**Rex Bowen**
**Chief Heating Engineer**
**County Architect's Department**
**County Hall**
**HERTFORD**
**ENGLAND**

# SEMINARS

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

### *"BUILDING ENERGY MANAGEMENT IN SCHOOLS"*

Seminar held in Milan, 21 April 1989

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The main object of this seminar was to verify the state of the art of the technology, to give the possibility to present theoretical concepts as well as experimental results of this system, to push the general interest of all persons involved in the School Management.

The seminar has been organized by italian Working Group of Annex XV "Energy Efficiency in Schools", sponsored by REGIONE LOMBARDIA.

<u>Paper presented in the Seminar</u>

| | |
|---|---|
| Opening of the session | L. Forcellini |
| PFE and IEA activities | C. Boffa |
| Activity of ANNEX XV "Energy Efficiency in Schools" | R. Lazzerini |
| Activity of ANNEX XVI "Users interfaces and system integration" | P. Cavallari |

| | |
|---|---|
| Activity of ANNEX XVII<br>"Evaluation and emulation techniques" | A. Mazza |
| "U.K. Overview of BEMS in Schools" | M. Patel |
| "Experiences in Durham County Council" | J. Motteram |
| Experiences in telemonitoring and control systems for schools in Italy | M. De Renzio |
| Organisation of a service of telemonitoring and control for central heating plants | G.L. Denoto |
| Results of operation of A.N.C.P.S. in telecontrol of schools in Vicenza | M. Michelangeli |
| Telemonitoring and control systems in schools: some practical results | L. Del Bo |
| Practical results from operation of a telemonitoring system in Verona | F. Chovari |

**Presentation of Manufacturers, experiences in Telecontrol systems in School Buildings**

| | |
|---|---|
| - G. MARTINI: | LANDYS & GYR |
| - G. CAMAGNI: | PARTERN DATA |
| - E. MILANESE: | TECNOENERGY BYTEL |
| - A. TREVISI: | STAFA CONTROL SYSTEM |
| - P. FLORENZANO: | RENOM |
| - A. BORCELLINI: | CALEFFI |
| - B. FORNARA: | HONEYWELL |

## 1. INTRODUCTION

Before the advent of EMS, most schools had simple time clocks or at most an optimiser. The heating systems were not well controlled; the schools were either too hot or cold and there were few zone control facilities. EMS changed all that. EMS's main benefits were felt to be:

- to provide a comfortable environment. This is the most important benefit. EMS do not just stop overheating but also improve conditions in schools where there is underheating;
- to provide better control of plant. Apart from optimum start/stop and compensation controls, most EMS also give much better zone control facility;
- the third main benefit is that EMS of course saves energy; control of temperature and control of plant are the main ways in which EMS saves energy and eliminates waste;
- the fourth benefit is that it provides an excellent tool for premises management. It not only tells engineers what the conditions in any school are like but also gives them early warning of plant failure.

## 2. CHARACTERISTICS OF BEMS SYSTEMS

Over the past ten years computer control of energy systems has become common. Most of the systems presently in use are based on one control computer per building.

With the maturing of this technology, systems have been developed which use one centralized computer to control many buildings. By use of telecommunication networks, it is possible to control buildings that are separated by many kilometers. When management of more than a few buildings is required, these networks are more cost effective in terms of equipment and labour than the stand alone systems.

School divisions which have several buildings controlled by a centralized administration are particularly amenable to this technology, which offers a large potential for achieving savings in energy and maintenance costs.

The overall energy management concept is to use a central processor (computer, CPU) located in divisional headquarters, to control the HVAC systems in the remote school buildings.

Central control of building systems offers a number of logistical benefits to school divisions. The cost of this type of system can be less than the cost of achieving equivalent control with stand-alone controllers in each building. The increased awareness of systems operations allows central administration to improve budgeting for energy, equipment and labour requirements, and to improve maintenance scheduling. As a bonus these systems can be readily expanded for security control and loss prevention purposes.

## 3. THE CONTROL PROCESS

The central processor makes control and energy optimization decisions based on internal programming (time scheduling, set and alarm points, control algorithm), in response to information received from the Field Processor Units (FPU) located in each school.

Each FPU receives and translates signals from sensors located throughout the school, and sends this information on to the CPU at divisional headquarters.

The CPU tests this information against its program and decides whether a control action is required. When an action is required to be performed, control information is sent back to the FPU in the appropriate school. From the FPU this information is passed on to the proper actuator module (eg motor switch, proportioning valve, etc.) which implements the required action via pneumatic and/or electric control mechanisms.

## 4. CONTROL FUNCTIONS

The outstations installed in schools vary according to the size of the schools and the number of zones. Generally, parameters monitored by the outstations include:

- external temperature
- internal temperature in all zones
- boiler flow and return temperature
- fuel meter readings

All these are generally monitored every half hour and stored in the outstation memory.

In case of power failure, the outstation has a battery back up. The outstations also carry out the following central funcion:

- optimum star/stop
- compensation control
- frost protection
- boiler sequencing
- holiday schedules

Outstations also monitor plant alarm conditions like:

- pump trip
- high limit stat
- boiler lockout

If any of these occur, then the outstation would automatically ring the central station and log the alarm. Some authorities have also connected the schools security alarms system to EMS, so that if the intruder alarm was activated at night, then an alarm would be raised through the EMS at the central station.

## 5. RESULTS OF THE WORKSHOP

The results and conclusions of the presentation, the discussion and the final round-table may be summarized as follows:

- centralized Energy Management Systems, with a central processor unit and many peripherical stations, as reported and illustrated during the workshop, are considered very interesting and suitable for school operation;
- the interest of school managers and administrators is mainly addressed to the possibility of operating many school buildings with one single system;
- according to the experience presented by many users and manufacturers, considerable energy savings may be attained;
- in existing systems, energy and money savings in the range of 20 to 40% are reported, depending on climate, number of buildings connected to one system, size of buildings, time of operation, etc.;

- some objections exist about economical advantage to install and operate a sophisticated central control system, when the schools are equipped with very simple heating system provided with only a thermostat;
- while it seems that there are no problems with new systems, some concerns exist regarding maintenance cost, as systems age.

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

### *"PASSIVE SOLAR DESIGN IN SCHOOLS"*

Seminar held in Cambridge, 31 May 1989

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This seminar has been organized by the International Energy Agency and the Building Professions Eastern Region Energy Group, with the intent to provide a forum for international discussion on latest developments for the optimum use of sunshine for warmth and lighting.

**Paper presented in the seminar**

| | |
|---|---|
| Opportunities for use of passive solar energy in educational buildings | D. Curtis<br>Energy Manager<br>Essex County Council<br>Chelmsford, Essex, England |
| Passive solar design: the Local Authority experience | D. Poole<br>Welsh School of Architecture, Cardiff |
| Energy performance assessment of Lool junior and infant school | D.K. Alexander<br>N.D. Vaughan,<br>H.G. Jenkins,<br>P.E. O'Sullivan |

| | |
|---|---|
| Passive solar buildings and bioclimatic architecture in Italy | V. Corrado<br>Energy Department<br>Politecnico of Torino |
| Two retrofitted buildings with passive and hybrid systems in Italy | S. Zabot<br>Energy Issue Department<br>Regione Lombardia<br>Via F. Filzi, 22 - MILAN |
| DES project on guidelines on Passive Solar Design and general U.K. overview | Prof. B. Norton<br>University of Ulster<br>(formerly at Cranfield<br>Istitute of Technology) |

An indication of the interest and success of this meeting may be given by the number of Participants, about 60, with 10 coming from Italy, and by the number and technical level of the papers presented, followed by an interesting discussion covering all topics.

Main points presented and discussed are the following:

- the local Authorities in U.K. consume about 20 million tons of coal equivalent energy per annum; this represents about 6% of the Nation's energy consumption, and two thirds is consumed in educational buildings;
- a decline in the number of pupils in schools in UK is in progress; the primary school population has fallen by about 20% since 1973 and the secondary is expected to drop by nearer 30% by 1991.

A similar situation exists also in Italy.

- it is unlikely that a significant programme of construction of new school buildings will take place in the forthcoming years. This means that if passive techniques are to be used to reduce fuel consumption, they are more likely to make an impact if employed in retrofitting, remodelling or upgrading existing accomodation;
- passive solar design in its most basic form is to utilizing free heat and light when required and available, but protection must be provided against overheating;
- an atrium provides a most attractive increase in amenity for minimum energy use. In Nabbotts School in Essex an Atrium has been incorporated with no extra energy requirements; the area is in addition to teaching space and although unheated is used for cloakrooms and other facilities allowing maximum use of heated teaching space. The atrium roof can be opened mechanically during warm weather;
- some smaller schools were built with a small courtyard or quadrangle which does provide the opportunity of adding a transparent roof to form a pleasant atrium. This does provide extra amenity, reduces energy consumption and provides an excellent means of increasing the capacity of a school. Atria have been installed in other schools in Essex, including Barnes Farm;
- Adding a conservatory to the south face of a heavy poorly insulated wall can also provide extra amenity and reduce overall energy consumption;

- As a conclusion, there is a great potential for use of passive solar energy in school buildings;

To realise this potential, technical barriers must be overcome; design, tools and performance data must be provided; familiarity with design concept must be increased.

Institutional barriers should also be lowered, and preferential funding facilities for energy investments offered to ensure passive solar is considered in design requirements and guidelines.

The technical tour on June 1st, to actually see some retrofitting measures already installed in many schools, represented a positive conclusion of this meeting.

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

### "ENERGY RETROFITTING IN SCHOOLS"

Seminar held in Rome, 26 October 1989

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This seminar has been organized by E.N.E.A., in cooperation with I.E.A. with the intent to examine the situation concerning retrofitting measures, which can be implemented in the School area, considering two main sections:

- measures directed to improve the building envelope and structure;
- measures directed to improve the efficiency of the several systems operating within the School building.

The seminar was directed mainly to Governmental and Local Authorities who have the responsibility of the management of Schools, to commercial firms interested in "energy service" for schools, to any technical organisations involved in design and construction of Schools.

<u>Paper presented to the seminar</u>

| | |
|---|---|
| Activity of ENEA. Rational use of Energy | P. Pittimada<br>ENEA - Rome |
| Activity of F.I.R.E. | G. Ferrari<br>FIRE - Rome |

| | |
|---|---|
| Construction of school Buildings in Italy. | M. Guarineri Cannizzaro<br>Ministry of Education<br>Rome |
| Functions and actions of Ministry of Industry | A. Pela<br>Ministry of Industry<br>Rome |
| Activity of I.E.A. in the School sector: Annex XV "Energy Efficiency in School" | R. Lazzerini<br>Studio Lazzerini<br>Torino |
| Energy conservation in existing education establishments. U.K. overview | R. Bowen<br>Chief Heating Engineer<br>Hertfordshire County Council. U.K. |
| Schools in Rome Province: analysis from an energy point of view | A. Cellie<br>Education Dpt<br>Province of Rome<br>Rome |
| Possible application of solar systems to school buildings | G. Sorinello<br>Rome City Council<br>Rome |
| Retrofitting actions performed in Schools in Lombardia Region | L. Burzilleri<br>S. Zabot<br>Energy Dpt<br>Lombardia Region<br>Milano |
| Energy efficiency in Schools in Regione Lazio | C. Colizza<br>Energy Dpt<br>Regione Lazio<br>Rome |

| | |
|---|---|
| A methodology for energy audit in schools developped by ENEA | D. Guarino<br>ENEA<br>Rome |
| Use of models of dinamic simulation for energy evaluations | M. Arduindi<br>T. G: Biserna<br>M. Citterio |
| Energy diagnosis | L. Angelone<br>ENEA-FARE<br>Rome |
| Energy monitoring in Schools | M. Romanazzo<br>ENEA-FARE<br>Rome |
| The experiences & activities of Essex County Council | D.M. Curtis<br>Essex County Council<br>U.K. |
| Retrofits performed in Schools in Vimercate | M. De Renzio<br>Sinerga<br>Milano |
| Managing energy for School buildings | W. Bohnenschäfer<br>Gertec Consult Engin.<br>Essen (R.F.T.) |
| Energy efficiency of Schools in Livorno | C. Fantozzi<br>C. Rini<br>Energy Dpt<br>Livorno Council<br>Livorno |
| Retrofit actions in School building in Province of Trento | G. Carlino et al.<br>Energy Dpt<br>Province of Trento<br>Trento |

The reports presented considered the following main topics:

- evaluation of the energy consumption and of the energy savings opportunities;
- methodologies of diagnosis and evaluation of energy saving measures;
- monitoring and performance analysis of actual measures.

The main results may be here briefly summarized:

- many examples of retrofitting actions performed in Schools, both in Italy and U.K. have been presented and discussed, pointing out the potential of energy saving associated to such measures;
- considerable savings are estimated to have been made in educational establishment in the U.K. by retrofit measures and good house keeping;
- the majority of retrofitting measures is directed to increase the efficiency of the heating systems.
  One of the most effective energy saving measure seems to be the installation and proper maintenance of heating controls;
- many other retrofitting measures are directed to increase the thermal resistence of external surfaces of the building (walls, window, roof, etc) and to increase the efficiency of the heating systems;
- the importance of the impact of this problem in the public and private sector has been emphasized. A large energy saving campaign has been announced, planned by ENEA, with the aim to promote an efficient exchange of the knowledge on this subject with public and private administrations and to encourage energy consciousness in the country as a whole;
- the intermittent occupancy of schools with varying requirements during evenings and school holidays is the ideal ground for application of electronic controls, optimizer and compensator for smaller schools; boiler sequencers and full energy management systems (BEMS) for larger schools;
- Schools have often different areas with different requirements for ambient temperature, ventilation rate, time of occupation, etc. Retrofit actions aimed to properly zone the heating system have proved to be cost effective;

- the consumption of electric energy in educational buildings is steadily increasing. The greatest savings in electricity are achieved by converting from incandescent lighting to fluorescent luminaires;
- the large and active participation to this Workshop of many officials from central and Local Administration made possible a fruitful discussion on the primary importance of the involvement and committent of the Administration in any energy saving program.

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

## ENERGY IN EDUCATIONAL FIELD

Seminar held in PUCKERIDGE (HERTS), 2 May 1990

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The seminar is directed towards Heads of Schools and Governors, with the aim to demonstrate the need for energy savings, what has been achieved already, what the school can do to help, and how the energy theme can be incorporated into the school curriculum.

The important interface betwen professional energy management in schools and the curriculum requirements for energy education has been pointed out.

It is also important to understand the linkage between Energy, Economy, Environment, Education.

<u>Papers presented to the seminar</u>

| | |
|---|---|
| Scientific Assessment to present graphically the need for a general and determined commitment to husbanding finite Energy resources and defending the environment. The linkage between Energy/Economy/Environment/Education. | Andrew Warren |
| Equating the global needs to Educational Establishments and the Education of | Mukund Patel Department of |

| | |
|---|---|
| Good practice and guidance from the Centre in a Public Sector organisation. Technical measures: financial justification. | David Curtis<br>Energy Manager<br>Essex County Council |
| Good practice the Self Help Way. Experience from a Private School. Housekeeping; Monitoring; Motivating; Managing. | Mike Flett<br>Bursar: The Norwich School |
| Energy Strategy for future Managers in LEA Schools. Options for Partnership. Image and reality. Planning for good performance. | Alan Tyler<br>Deputy County Architect<br>Hertfordshire |
| Energy in the School Curriculum | Les Hewitt<br>CREATE |

**Energy in the curriculum**

Three fundamental questions must be considered:

1. Why and to what extent does energy need to be part of the school curriculum?
2. How can energy managers and teachers work co-operatively, and what are the mutual benefits?
3. Who needs to be involved in this work?

For the first question, "WHY"?, the general justification reflects:

- the need to protect the environment from the effect of unnecessary energy use;
- the need to conserve finite hydrocarbon fuels;
- the need to improve the national economic performance through lower costs arising from increased efficiency;

- The need of individuals to use energy prudently in their everyday lives;
- the need for individual schools and colleges to avoid waste and reduce costs.

For the second question, "HOW?", there are many possible methods, within the new framework, of dealing with energy in the curriculum. None is perfect or necessarily appropriate in every case. There are as many possibile methods as there are schools; each needs to be individually taylored.

It is essential to be aware of the conceptual nature of energy and the special demands this makes when designing learning experience for children.

Activities should be designed to change attitudes and behaviour, with the aim for a wide involvement of both pupils and staff.

Pubblicity, and information dissemination on a regular basis, are essential to maintain a high public profile, whilst due prominence should be given to tangible results.

Given the vast range of possible strategies, every school needs to develop its own approach to long-term energy management and the nature of its integration with energy education.

For the third question "WHO?", the short answer is: "everyone".

Strategies to achiave this may be purely school based or they might be externally supported. In the new climate surrounding local management, in U.K., more and more schools will look for help, outside their immediate circle, to the independent sector and outside Agencies.

Although there may be costs involved with some of the Agencies, if shared with other schools in a local consortium then the shared cost could be good value for money.

## The role of teachers

The role of teachers is obviously of prime importance; the teaching staff's commitment to energy conservation should be primarily altruistic, ecological, and morally based.

Teachers must prepare children for what is foreseen as a much more difficult future: the problem is the education of a to-day generation who to-morrow will take decisions.

This means that teachers must impart to children pro-energy conservation attitudes and teach them energy conserving behaviour. However, they are often unprepared and under-resourced for accomplishing this task.

It is therefore necessary to develop such resources necessary to support teaching staff and thus promote a high level of awareness amongst pupils and staff alike.

Teachers and their pupils need to discover how and why things work, how they and their actions relate to their environment, and how they can manage their energy use in the years to come.

<u>Energy economy</u>

Savings in energy expenditure can allow funds to be transferred to other areas of expenditure.

Schools can achieve savings in energy expenditure through:

- reducing the amount of accomodation occupied;
- identifying short pay bak opportunities;
- identifying longer pay back opportunities;
- ensuring that energy consumption is considered in the design of extensions and alteration;
- introducing improved energy management;
- raising the awareness of staff and pupils to the importance of energy conservation.

Schools can contribute to the national and global need to conserve fossil fuels and to reduce the emission of greenhouse gases.

It has been estimated that a 10% reduction in energy consumption may be attained through better housekeeping measures; these include:

- close windows and doors in cold weather;
- check thermostats and time control setting;
- switch off lights when not needed;
- attend to leaks promptly;
- discourage use of unauthorised heaters;
- check hot water temperature and reduce if necessary.

A saving in energy consumption in the order of 10% represents approximately £ 1000 per annum for a 240 pupil primary school and nearly £ 4000 per annum for a 1000 pupils secondary school.

The savings achieved in the schools management, in U.K., have been significant and confirm the potential for further savings. They represent a substantial contribution to the national effort to reduce the consumption of fossil fuels and the emission of greenhouse gases.

The savings achieved since 1978/79 represent the equivalent of 290,000 tonnes of coal, and a reduction in $CO_2$ emission of between 348,000 and 500,000 tonnes.

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

### *"MANAGEMENT AND MAINTENANCE IN SCHOOL SYSTEMS, WITH THEIR CONTRACTUAL ASPECTS"*

Seminar held in Rome, 26 September 1990

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Object of this seminar was the examination of the situation concerning contracts for management and maintenance in School Buildings and Systems, taking due account of new and future technologies.

The seminar was directed mainly to all people who have the responsibility of management and maintenance of schools, to consultants, teachers, Governmental and Local Authorities involved in the problems of school, to private or public organization who supply the fuel or the "heat service" for school buildings and systems.

After the Seminar, a visit to a modern school, with interesting technical solutions, has been organized, as here under reported.

<u>Paper presented in the Seminar</u>

| | |
|---|---|
| Activity of ENEA in the field of School System efficiency | D. Malosti, ENEA, Roma |
| Activity of I.E.A. in Schools: Annex XV "Energy Efficiency in School" | R. Lazzerini Operating Agent for Annex XV "Energy Efficiency in Schools" |

| | |
|---|---|
| Optimum comfort conditions in Schools, related to energy consumption | P. Lazzerini<br>Studio R. Lazzerini - Torino |
| General Survey on energy consumption in School Buildings in Italy | D. Guarino-ENEA<br>M. Barbato<br>Statistical Service of Ministry of Education - Rome |
| The problems related to operation contracts | M. De Renzio<br>SINERGA - Milano |
| Maintenance and energy efficiency. The U.K. view | M. Patel<br>Department of Education and Science - London |
| Planned maintenance in School Buildings | L. Chiara<br>Centro Edile - Segrate (MI) |
| Planned maintenance of Mechanical Systems in School Buildings: experiences and evaluation | P. Conti<br>Gas Energia - Torino |
| Telecontrols and advanced tecnologies, in the operation of School Buildings | P. Compagnoni<br>Agip Servizi - Rome |
| Consequences of a regular operation of mechanical systems in School Buildings | A. Pela<br>Assocalor - Rome |
| School Operation and Maintenance in Regione Lombardia | G. Meroni - G. Rottolo<br>Milan City Council, Energy Dept.<br>S. Zabot - Lombardia Region Energy Dept. |

*Operation and Maintenance*
of School Department in the

A. Cellie - Province of Roma
Education Dept.
Province of Rome
Rome

Prevailing of EEC Rules on national
bid and contracts procedures

A. Cacace
Bocconi University - Milan

Various types of contracts have been analyzed and investigated, in order to determine best choice at local level. Third party financing options have also been exposed.

The papers presented reflected mainly the situation existing in Italy: one paper presented also the U.K. view on the problems of Maintenance and Energy Efficiency.

During the Seminar the importance of maintenance has been duly stressed; maintenance is clearly expensive, but it is important to realize that failure to maintain is even more expensive. If maintenance is not carried out, the plant can break down suddenly, requiring emergency repairs which can be more expensive and can disrupt activities in the school.

A large scale survey on the situation of schools in Italy has been made, organized by ENEA and Statistical Office of Ministry of Education, extended to the entire territory of the country. This survey is not limited to energy consumption, but considers all aspects of schools: architecture, structure, age of construction, heating, lighting, noise, etc..

Processing of the mass of data collected during this survey is still under way, but the Authors have reported to this Seminar some interesting results concerning the management of the heating system, consumption of fuel and electricity, number of school involved, etc.

The problems of the planned maintenance of school Buildings have been considered in another report, pointing out the case of Regione Lombardia, with some 8.200 Buildings.

Many school buildings are in need of extensive repair and refurbishment, which presents an excellent opportunity for the installation of measures which improve energy efficiency.

So far, maintenance actions have generally been carried out only when repair work was considered unavoidable.

A new philosophy will be adopted: rather than replace like with like when repair and maintenance work has to be carried out, a planning of the measures to be taken on the total complex of building in the Region will be done, through the following phases:

- monitoring of the buildings;
- identification of the measures to be taken;
- evaluation of investment costs, setting of priorities, planning of actions;
- bids for practical adoption of the measures, according to the planning
- check-up of the results.

Planned maintencance of systems has also received due attention.

According to statistical results, the majority of malfunctions in systems are due to management and maintenance failures.

The following table has been presented giving the percentage of incidence for several items:

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|---|---|
| - management and maintenenance failures | 39% |
| - quality of materials | 25% |
| - components | 20% |
| - design or construction mistakes | 15% |
| - other | 1% |

A comparison between actual life time of systems components and the life we can have with a correct planned maintenance, has been presented: an increase in the order of 50-80% is generally recognized.

The optimum ambient conditions to be maintained within the school have been considered in another paper.

As for internal temperature, in Italy present regulation refer to "air temperature" measured with a normal thermometer in the center of the room, 1,5 m. above floor level.

In U.K. reference is made to "resultant temperature" which is the average value between mean radiant temperature and air temperature, and is measured with a globe thermometer 0.5 m above floor level.

The link between ambient internal conditions, external environment, efficiency of the systems, fuel consumption, pollution, has been evidenced.

Technical School of MONTEFIASCONE (near Rome, Italy)

The Technical School of MONTEFIASCONE represents some interesting architectual and technical solutions, which try to give a reasonable answer to the energy problem in term of cost, technology and architectual quality, by means of a system in which the solar component has a significant impact.

Built in the 80', the school has a main building, measuring 93.30 by 19.50 metres, 10.0 metres high. It is formed by five teaching blocks, each one measuring 17.10 by 19.50 metres, 10.0 meters high.

The five blocks are crossed by the central distribution block which divides them, thus according to simple geometrical rules as well as to the functional and distribution requirements.

In the south prospect of the building technological solutions have been adopted in order to take the maximum profit of the solar radiation:

- the glass window covering the hall
- the air solar collectors
- the wide windows, screened by sunshades

The glass windows on the hall act as passive solar devices, due to greenhouse effect inside the hall, with their overall surface of 150 $m^2$.

<u>Heating system</u>

The heating system of the School has been designed according to the following parameters:

| | |
|---|---|
| - minimum winter external temperature: | -3 °C |
| - internal temperature: | 20 °C |
| - classrooms ventilation: air changes per hour: | 5 |
| - services ventilation: air changes per hour: | 2,5 |

For the base load, a set of fan-coils is installed in every room, connected to a hot water circulation system with conventional gas fired boilers.

For the ventilation air, a separate system is installed with the solar air collectors operating as pre-heaters, and air handling units for the final adjustement.

Main data of this system are:

- overall heating surface of air solar collectors: 389 $m^2$
- number of air handling units: 4
- air flow-rate for each air handling unit: 11,000 $m^3/h$

The external supply air passes first through solar collectors where it is pre-heated, and then reaches the air handling units where temperature and R.H. are adjusted according to external conditions.

Air is then delivered to classrooms through a complex ductwork: in every room a post-heating local coil, controlled by a thermostat and a three-way valve, allows the ambient set conditions, 20 °C, to be maintained.

Air is extracted from every classroom, and by means of a return duct it may be either returned to the handling unit, in the starting stage, or completely expelled when the system is in its steady-state after arrival of students in the classrooms.

## I.E.A. INTERNATIONAL ENERGY AGENCY

## ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

## ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

# "ELECTRICITY ECONOMY IN SCHOOLS"

Seminar held in Cambridge, 10 October 1990

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The seminar was been organized with the intention to assist Head Teachers, Bursars and Governors, who are now responsible, in U.K., under Local Management of Schools, for their schools electricity budget.

Although much has been done to improve the thermal insulation of schools and to increase the efficiency of heating systems, so far the consumption of electricity has received relatively little attention.

In U.K. between 1978 and 1985, electricity consumption in educational buildings increased by 14%; the electricity costs per pupil have risen, in real terms, by 32%. This increase may be explained by the growing use of computers and other electronic equipment. The increasing use of schools for community activities, particularly in the evenings, may also have added to the demand for electrical energy.

Electricity still represents a relatively small proportion of total energy consumption but it is an increasingly significant element in overall energy costs.

It must be pointed out that electricity is the most expensive form of energy used in schools; consequently, reducing electricity consumption may save more money than many other measures.

Papers presented to the seminar

| | |
|---|---|
| Use of electricity potential for economy. | Eddie Forfar<br>Norkfolk County Council |
| Working with tariffs | Alex Spivey<br>Eastern Electricity |
| Good management of lighting and computers | Mike Flett<br>Bursar<br>Norwich School |
| Lighting and equipment controls | Robin Aldworth<br>Thorn Lighting |
| Domestic hot water | Trevor Rowe,<br>Eastern Electricity |

Potential for savings in electrical energy

The average consumption of energy in schools, in U.K., may be considered divided as follows:

- Space heating: 60%
- water heating: 15%
- lighting: 15%
- cooking: 5%
- other: 5%

It is expected that adopting suitable measures of energy conservation it will be possible to reduce the energy requirements and consumption by not less than 15%

Such savings in electrical energy, in schools, may be accomplished through actions in three main directions:

- contracts and tariffs;
- lighting system;
- hot water production.

Contract and tariffs

Electricity is extremely flexible in the way it can be used; it can cover amongst other things lighting, heating, refrigerators, hot water production, swimming pool operation, etc. With such varied use coupled with relative ease of metering the Electricity Supply Industry have devised a number of tariffs which have been tailored to suit different consumers' requirements, both in U.K. and Italy.

Not only are the tariffs tailored for specific use as domestic, industry, schools, hospitals, etc, but are themselves subdivided into different charges which reflect the way costs change with various features of the supply.

The efficient operation and maintenance of electrically powered plant and its correct loading are essential in the search for the economic use of electricity.

Lighting control

The possibility to attain sizable savings in electric energy use, in school systems, is met by means of an efficient lighting control, through the following steps:

- provide appropriate lighting standards
- use most suitable lighting systems
- use most suitable lighting equipment
- control the time of use
- maintain the system in efficient use.

The potential for economy in electricity use in schools by simple good housekeeping by staff and pupils is generally greater than any other form of energy use.

Potential savings by means of short to medium term capital investment is also greater and more wide ranging than for any other type of fuel.

The measures to be taken in the frame of "good housekeeping" may be the following:

- switch off lights when not required and ensure that lights are not left on in unoccuppied classrooms, assembly hall, gymnasium, sport halls, etc.;
- take every opportunity to switch off lights whenever natural daylight is adequate: open blinds and curtains;
- reduce the amount of artificial lighting in toilets, corridors and general circulation areas to the minimun necessary for safety; consider the use of lower wattage lamps or miniature fluorescent lamps;
- ensure that external lighting for security or other purposes is not left switched on during the day;
- prohibit the use of supplementary electric heaters unless absolutely essential;
- avoid the simultaneous use of heavy power consuming electrical equipment, particularly during the months of November to February, when maximun demand changes are applied.

<u>Hot water</u>

For the production of hot water, by means of electricity, two different types of systems are generally used:

- stored systems, for operation in off peaks times, during the night;
- point of use systems, for operation in any moment of the day.

In the stored system, the cylinder with a capacity ranging from 120 to 450 liters, is equipped with two internal electric heaters, the first in the lower part of the cylinder, in operation from 24:00 to 7:00, controlled by a timer and a thermostat; the second in the upper part, manually controlled, in operation in other times of the day.

This combination allow the school to use the cheaper night-rate electricity rate as much as possible.

In the point of use system there is a low capacity tank, to give the immediate availability of 7-8 litres hot water, and a heater, gas fired or electricicity operated.

In many existing schools, there is a central boiler, oil or gas-fired, with a common system for space heating and hot water. The extensive pipework system gives rise to high heat losses, making the system expensive to run. It is also difficult to meet the varying requirements for hot water in the kitchen and other parts of the school.

When retrofit measures have been taken, leading to separate space and water heating system, considerable savings in running costs have been attained, ranging up to 20%.

It has been reported that conversion of the system can pay for itself in five years.