INTERNATIONAL ENERGY AGENCY
energy conservation in buildings and
community systems programme

International Energy Agency
Energy Conservation in Buildings
and Community Systems Programme

Energy Efficiency in Schools
Annex 15
Final Report
January 1992

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This report is part of the work of the IEA Energy Conservation in Buildings & Community Systems Programme.

Annex V Air Infiltration and Ventilation Centre

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ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

FINAL REPORT

Torino
January 1992

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FOREWARD

This *Final Report* summarizes the complete work performed by Annex XV Participants in two and one half years activity, presenting a set of data and information on energy consumption in School Buildings and Systems. The material presented represents the accumulated knowledge and experience of the experts taking part in this work.

The aim of this Report is also to provide School Managers and Operators with advice on methods and procedure, to operate their systems efficiently and thereby reduce their energy consumption and cost.

The work was started in 1988, based on a bilateral agreement between U.K. and Italy, with a duration of 2½ years.

In total seven meetings were held of the formal working group of Annex XV, and six Seminars were organized both in Italy and U.K. on special topics concerning School Management.

The names and affiliation of the experts that have taken part in this work listed below.

They represent a wide spectrum of backgrounds, from school Authorities to researchers, educators, and consultants.

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1. GENERAL

The International Energy Agency (IEA) was established in 1974 within the framework of the Organization for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among the twenty-one IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources and energy research development and demonstration (*RD&D*). This is achieved in part through a programme of collaborative RD&D consisting of forty-two Implementing Agreements, containing a total of over eighty separate RD&D projects.

1.1 Energy Conservation in Buildings and Community Systems

As one element of the Energy Programme, the IEA sponsors research and development in a number of areas related to energy. In one of these areas, energy conservation in buildings, the IEA is sponsoring various exercises to predict more accurately the energy use of buildings, including comparison of existing computer programmes, building monitoring, comparison of calculation methods, energy management systems, as well as air quality and inhabitant behaviour studies.

Sixteen countries and the European Community have elected to participate and have designated contracting parties to the Implementing Agreement covering collaborative research in this area. The designation by government of a number of private organizations, as well as universities and government laboratories as contracting parties, have provided a broader range of expertise to tackle the projects in the different technology areas than would have been the case if participation was restricted to governments. The importance of associating industry with government sponsored energy RD&D is recognised in the IEA, and every effort is made to encourage this trend.

1.2 School and Related Energy Consumption

Schools present unique problems in terms of internal environment. They generally have short periods of occupancy, weekdays only with long holiday periods, factors which favour a light construction and intermittent heating.

Large amounts of energy are generally required for the operation of all systems and services within the schools, and large amounts of energy are reported to be wasted.

Considering the growing importance acquired by the education service in many countries, the growing number of people and organizations directly or indirectly associated with this service, and the number and size of schools, the necessity of a more rational management of the energy involved has been generally recognized.

The fuel cost may only be a small part of the total budget for a school, in the order of 3 to 5% of the total, but it represents one of the most significant and controllable items.

It must also be pointed out that energy conservation measures undertaken in school buildings and systems not only save fuel and money, but also reduce pollution and improve the comfort and morale of staff and pupils. A more comfortable teaching and learning environment leads to more effective use of human resources, even if the financial benefits of this improvement are difficult to quantify.

Thus a new Annex in the framework of I.E.A. activity, Energy Conservation in Buildings and Community Systems, was discussed, and resulted in a bilateral agreement between U.K. and Italy for the management of Annex XV *"Energy Efficiency in Schools"*.

In this field there is scope for a wide ranging research programme, with participation of both countries, whose aim is to demonstrate that it is possibile to reduce the amount of energy counsumed in school facilities, without adversely affecting the quality and the high standard required for the services provided.

1.3 Objectives of Annex XV

Considering Annex objectives, the main challenge has been to compare experimental results over time, from one place to another. With this problem solved, findings in one country can also be used in another, and consequently extensive national research programs can be rationalized. The task has been therefore directed towards finding appropriate parameters to describe the energy consumption of schools and in providing the Participants with generalized information of the energy saving potential of different measures which can be implemented in school buildings and systems.

The main objectives of Annex XV may summarized as follows:

- identification of the situation existing in both countries, related to problems associated with the school;
- identification of energy consumption in the various systems normally existing in schools;
- evaluation of the energy saving potential of different measures which can be taken in school buildings and systems;
- recommendations of the use of new and existing energy management technologies;
- provision of maintenance advice to assist in efficiently operating systems and equipment.

1.4 Activity of Annex XV

To fulfill the objectives of Annex XV, two working Groups were formed, one in U.K. and the second in Italy.

Each Group met separately in its own country to examine data and all other program details, while general meetings of all Members took place usually at the same time as the seminars.

The work performed by the two Working Groups, in U.K. and Italy, have been the following:

- collection of statistical data and other elements related to schools, in both countries;
- collection and analysis of case studies of retrofitting actions in Schools performed in U.K. and Italy;
- organisation of Seminars on special topics concerning Schools, both in U.K. and Italy;
- regular meetings of the Working Group for analysis of results, discussion of reports, exchange of information.

The organization of Seminars on selected topics relevant to school management, with presentation of papers prepared by experts, followed by open discussion has proven to be most effective for exchange of information, collection of data, and up-dating of results.

Much of the data and results in this report have been drawn from papers presented to such seminars, as well as the discussion during and after the Session. Contacts established with other experts participating in the Seminars has provided a longer term forum for international collaboration which will last much longer than the necessarily restricted Annex life.

2. SITUATION EXISTING IN U.K. AND ITALY

The first step has been to determine the dimensions of the problems associated with schools in both countries, considering key parameters and characteristics,related not only to energy, but also to other general aspects of the life in each country, factors which eventually affect energy and energy consumption.

The aim is to understand the differences and the similarities between the two countries, and to what extent the results obtained in one country may be applied in the other.

Comparative data concerning this aspect of the problem both in U.K. and Italy have been the following:

- surface and population;
- climate conditions;
- school population;
- school buildings;
- design standards for schools;
- systems used in the school;
- type of fuel used in school systems;
- energy consumption.

The availability of data on these items is different when we consider U.K. and Italy.

In the U.K. a lot of data concerning energy consumption, school characteristics etc. may be found in various publications.

In Italy data on a national basis concerning the same items are generally missing. Many results are available for some Regions, who have already made wide investigations both in schools and in energy efficiency.

2.1 Surface and population

Data concerning overall population have been taken from recently available statistic data.

As for school population, figures relate to Primary and Secondary Schools, omitting Universities and Nursery Schools.

In Figure 1 the maps of U.K. and Italy are shown on the same scale, with some statistical data which demonstrate the similarity of the two countries.

U.K.

- area	km^2 244,000
- population	57,000,000
- number of pupils	8,000,000
- ratio number of pupils/population	0.14

Italy

- area	km^2 301,000
- population	56,000,000
- number of pupils	8,650,000
- ratio number of pupils/population	0.15

Population of the two countries is of the same order of magnitude, while the overall surface of Italy is some 15% larger than the U.K.

As for School population, the figures for Italy are slightly higher, and consequently the ratio number of pupils/population is higher but the scale of the problem seems to be similar for the two countries.

In Figure 2 the two maps are superimposed: the central zones of both countries are similar; in U.K. the concentration of population and industrial facilities is mainly in the south while in Italy the opposite applies.

2.2 Climate conditions

The climate conditions recorded in U.K. and in Italy are here reported with the following data:

a) altitude above sea level	[m]
b) mean annual temperature	[°C]
c) mean temperature in January	[°C]
d) mean temperature in July	[°C]

2.2.1 United Kindom

	(a) [m]	(b) [°C]	(c) [°C]	(d) [°C]
Dundee	45	8.5	2.6	14.8
Edinburgh	134	8.6	3.1	14.5
Glasgow	5	8.9	3.1	14.7
Manchester	75	9.4	3.3	15.7
Birmingham	163	9.5	3.3	16.0
London	39	10.7	4.1	17.7
Cardiff	62	10.1	4.1	16.3
Plymouth	27	10.7	5.9	15.9
Southampton	3	10.7	4.5	17.3

2.2.2 Italy

	(a) [m]	(b) [°C]	(c) [°C]	(d) [°C]
Torino	238	11.2	1.8	19.2
Milano	121	12.8	0.5	21.5
Venezia	1	12.9	2.4	22.2
Trieste	11	14.6	4.7	23.9
Genova	21	16.1	7.5	23.7
Bologna	60	13.6	1.2	24.0
Firenze	51	14.4	5.7	24.5
Perugia	493	13.3	4.5	22.5
Roma	17	15.4	7.5	24.2
Pescara	10	14.8	7.4	22.3
Napoli	30	16.9	9.0	24.9
Bari	12	15.7	8.8	22.7
Palermo	31	19.1	12.2	25.8
Cagliari	7	16.9	9.3	24.5

Mean annual temperature and mean January temperature for a certain number of towns in U.K. and in Italy are shown in the maps in Fig. 3. In Italy there is a considerable scattering of the winter temperature over the length of the country, with consequent variation of the energy demand from heating systems.

2.3 School population

In recent years a continuous reduction in the number of pupils has been recorded both in U.K. and in Italy.

Figure 4 reports the situation in U.K. and in Italy.

For Italy, a break-down is also available, reported in Fig. 5, of the three components of school population, according to the age of pupils:

- Elementary school	6-10 years
- Primary school	11-14 years
- Secondary school	14-18 years

It shows a reduction in the number of pupils for all kind of schools, except secondary schools, where there is a slight increase. The overall combination of the three components gives a reduction over time.

2.4 School Buildings

In U.K. there are 35,200 schools, as a total, with on overall useful floor area of 76,000,000 m^2 divided as follows:

- Primary schools:	n° 25,300	29,000,000 m^2
- Secondary schools:	n° 5,300	39,000,000 m^2
- Others:	n° 4,600	8,000,000 m^2
	n° 35,200	76,000,000 m^2

Considering the floor area for each school we have the following results:

- Primary schools:	1,100 m^2/school
- Secondary schools:	7,300 m^2/school

35% of the schools were built during the boom in 1950-1970.

In Italy, according to the last general survey conducted by ENEA, there are 37,900 schools, divided as follows:

- elementary schools	24,300
- primary schools	9,100
- secondary schools	4,500

Detailed information on floor areas are not available, but some data is available on overall floor areas of all schools, the percentage distribution of schools in the different geographic zones of the country, and the year of construction of the building.

Total floor area of schools in Italy: 86,000,000 m^2

Number of Schools in the different geographical zones in Italy:

- North	54%
- Center	13%
- South and Islands	33%

Year of construction of the Schools in Italy:

- before 1900	13%
- 1900-1940	15%
- 1940-1970	44%
- after 1970	28%

Owing to the reduction in the number of pupils, the construction of new buildings for schools has been greatly reduced, both in U.K. an Italy.

The situation in U.K. is reported in Fig. 6, which shows the number of schools built in the years 1969-1988, and the continuous decrease since 1973.

Complete records are not available for Italy but the trend is similar; after a construction boom of new school buildings in the 60's there was a marked decrease after 1975.

2.5 Design standard for schools

In both countries there are specific standards for design and operation of school buildings and systems.

A survey has been made by Annex XV to identify all relevant parameters, by means of forms specially prepared for this study, as reported in Fig. 7 and 8.

An obvious difference is the outside winter design temperature, which sets a marked difference betwen U.K. and Italy.

2.5.1 Winter design temperature

Although the two countries have the topographical similarities already shown, the different geographical position affects the climate conditions, as reported in Fig. 3.

As an island, U.K. has a more uniform distribution of temperature, while Italy has a north continental area and a long "boot" extending south into the mediterranean sea.

From calculation standard point of view, in U.K. there is only one "Zone" with a conventional design outside winter temperature of -1 °C, as follows.

Zone	design temperature [°C]	D.D.	heating days
-	-1	2,231	

On the other hand, Italy is divided in six so-called "climatic zones", each one having a different value of conventional minimum winter design temperature, and a different figure for the associated value of Degree-Day, decreasing from North to South and also related to altitude above sea level. The heating period, in terms of number of heating days, is also different, as here under reported, where two "zones" "A" and "B", with less than 900 D-D have been considered together for simplicity.

The base temperature for calculating D.D. in U.K. is 15.5 °C, while in Italy is 20 °C.

Zone	design temperature [°C]	D.D.	heating days
A+B	+2 to +5	< 900	120
C	0 to +2	901 to 1400	150
D	-3 to 0	1401 to 2100	160
E	-15 to -3	2101 to 3000	180
F	-20 to -15	> 3000	240

Consequently, it is difficult, in Italy, to speak in term of "average" values for outside temperature, energy consumption, time of operation, etc.

Generally speaking, in order to make meaningful comparisons with the situation existing in other countries, such as U.K., it is better to take separate figures for three different situations:

- Northern Italy
- Central Italy
- Southern Italy and the large Islands (Sicily and Sardinia)

2.5.2 School days

We have the following situation:

	U.K.	I
- school days	195	210
- school days in the winter season	160	variable
- mean length of school days (hours)	7	6

2.5.3 Lighting

Artificial lighting levels specified in schools, according to national standards, are as follows:

	U.K. [lux]	I [lux]
- classrooms	350	300
- circulation areas	150	100
- sport areas		200
- workshops	350	300
- medical		

2.5.4 Design ventilation requirement

These requirements are given in different units: in U.K. air flow is expressed in cubic meters per hour, while in Italy air flow is expressed in air changes per hour.

	U.K.	I
- air per person per hour		
m^3/h pupil	30	
- air changes per hour		
(Primary)		2.5
(Middle)		3.5
(Secondary)		5.0

2.5.5 Winter internal design temperature

	U.K. [°C]	I [°C]
- classrooms	18	20 ± 2
- circulation areas	15	20 ± 2
- sport areas	15	20 ± 2
- workshops	14	20 ± 2
- medical	21	20 ± 2

2.5.6 Heat loss from the Building fabric

In U.K. the average thermal transmittance coefficient for opaque areas of walls and roof should not be greater than 0.6 $W/m^2 \cdot K$.

In Italy, according to present regulations, the transmittance coefficient "U" ($W/m^2 \cdot K$) for opaque areas is a function of the mass "M" (kg/m^2) of the structure considered, as shown in the following table:

Vertical external walls

M	20	50	100	≥ 200
U	0.37	0.53	0.7	0.93

Roofs

M	100	200	≥ 300
U	0.5	0.70	0.86

2.5.7 Area per pupil

According to specifications existing in U.K., new primary schools have about 4.5 m^2/pupil and new secondary schools about 7.5 m^2/pupil.

In Italy present regulations require a minimum area per pupil variable with the total number of pupils in the School (i.e. with the size of the buildings) according with the following table.

The number of pupils per classroom shall not exceed 25.

Number of classrooms	Number of pupils	Area [m²/pupil]
5	125	---
6	150	11.02
7	175	---
8	200	---
9	225	9.61
10	250	---
11	275	---
12	300	8.78
13	325	---
14	350	---
15	375	8.50
16	400	---
17	425	---
18	450	8.10
19	475	---
20	500	---
21	525	8.45
22	550	---
23	575	---
24	600	8.06
25	625	---

2.6 Systems used in Schools

Statistical data for the type of systems usually employed in the schools is generally not available.

According to general knowledge and to preliminary results of recent surveys, the majority of less modern schools are equipped with normal heating systems using hot water, forced circulation and radiators: sometimes there are radiant panels. For gymnasiums and swimming pools there are ventilation systems.

In new schools, there are often mechanical ventilation systems, at least in service zones, in order to attain the air change values specified in standards. In older schools there is generally only natural ventilation.

From this point of view, the situation is similar both in U.K. and Italy.

2.7 Swimming pools

Swimming pools incorporated in the same structure of the school building is more common in U.K., while this solution is not usual in Italy.

The latest and most modern major schools in Italy are sometimes equipped with an indoor swimming pool, but generally the situation of the two countries is quite different.

This may affect the energy consumption, and we must take account of it in comparing figures, as shown in the following table which reports average figures for energy consumption in different cases, in U.K.

Performance Yardsticks for Schools
[kWh/m² per year]

Type of school	Energy Efficiency Rating Good	Fair	Poor
Nursery	< 370	370-430	> 430
Primary, no indoor pool	< 180	180-240	> 240
Primary, with indoor pool	< 230	230-310	> 310
Secondary, no indoor pool	< 190	190-240	> 240
Secondary, with indoor pool	< 250	250-310	> 310

2.8 Temperature of D.H.W.

Limit temperature for domestic hot water, in U.K., is 43.5 °C.

In Italy, the limit temperature specified for the centralized production of hot water is 48 °C, with an allowance of 4 °C, which gives a maximum temperature of 52 °C.

2.9 Type of fuel

In Italy, up to the eighties, the school boilers were operated mainly on light fuel oil (sulphur content less than 0.3%), with a small proportion operated with natural gas.

According to the last survey made by E.N.E.A. today the proportion is different.

- fuel oil:	48%
- natural gas:	41%
- other (LPG, coal, etc.):	11%

Figure 9 shows the situation of fuel consumption in U.K. and in Italy, for 1978/79 and 1989/90.

2.10 Energy consumption

With data on consumption of energy in schools currently available in Italy and U.K., it is sometimes difficult to compare the two countries.

In Italy there is some data from limited surveys conducted in some Regions. There are also some other figures obtained indirectly by evaluation of total energy consumption.

Some additional data is now available with the results of the extended survey conducted on all schools in Italy by ENEA.

The base units used in available statistics are also different, both in U.K. and Italy; sometimes data is given as "energy" per pupil, or energy per square metre, per cubic metre, per classroom, etc; sometimes as "money" per pupil, etc.

An attempt has been made to correlate the various and non homogeneous data arising from survey in U.K. and Italy, with the following tentative results.

2.10.1 Thermal energy

Figure 10 shows the total energy consumption for heating systems in school buildings in U.K. during the years 79/80 to 85/86.

For heating season 1987/1988, a specific consumption of 7.6 GJ/pupil is reported.

In Italy, according with the results of the previously mentioned survey we have the following data.

- Elementary Schools:	6.45 GJ/pupil · a
- Primary Schools:	4.75 GJ/pupil · a
- Secondary Schools:	3.5 GJ/pupil · a

The weighted average over the whole territory is about 4.8 GJ per pupil per annum.

This value is substantially lower than the value shown for U.K.: 7.6 GJ per pupil per annum, but for northern Italy, which has comparable climate to U.K., the figure is 7.2 G.J. per pupil per annum.

We must always take into account the difficult problem of setting an "average" value for all Italy.

2.10.2 Electric Energy

In Italy, using the data from the recent ENEA survey, we have the following results, which compare the kWh (electric) consumed per pupil per annum, and kWh consumed per m^2 of floor surface per annum.

	$kWh/m^2 \cdot a$	kWh/pupil · a
- Elementary schools:	9.9	94.3
- Primary schools:	10.2	96.3
- Secondary Schools:	13.3	115

2.11 Administration

There is a difference in the way that schools are administered, between U.K. and Italy.

In U.K. the responsibility of administration of educational buildings, and systems is committed to the Local Education Authorities (*LEA*).

The LEA is part of the Metropolitan Borough or County Council which is responsible for provision of all nursery (optional), primary and secondary education in its area. For example the LEA of Essex County Council is responsible for 800 schools in the County, including new building, maintenance, salaries, equipment, fuel, etc, It fixes staffing levels for each school and decides when schools should be improved, amalgamated or closed, etc.

Matters of policy are determined by the Education Committee made up of elected (political) members of the Council. Day to day running and matters concerning the operation of individual schools is supervised by a school "Board of Governors" who are nominated by the Council.

From April 1990, all secondary and most primary schools have been given responsibility for most of their budget. The school governors will take responsibility for expenditure on staff, equipment, fuel, etc. So any savings made in energy consumption will be for the schools to keep and spend on anything the governors wish, eg. computers. On the other hand, if they spend too much on energy, they will have to make cuts elsewhere. This gives the schools a strong incentive to save energy

In Italy the situation is more complicated.

The Central Administraion (state govt.) provides the salary for the personnel of all kinds of state schools.

The ownership of the schools is more articulated:

- Schools of arts (licei artistici) belong directly to the State;
- Scientific high schools (licei scientifici) and some technical schools belong to district administrations (provincie o regioni);
- all other schools (nursery, primary, secondary, high schools) are owned by local municipalities.

The owners are responsible for operation and maintenance expenses.

3. CASE STUDIES

In the frame of work performed by ANNEX XV, Working Group Members agreed that it was necessary to acquire more information on energy saving measures which can be undertaken in school buildings and systems, their technical and economical potential, costs, payback time, etc.

For a better understanding of the situation existing in both countries, during June-July 1989 a detailed analysis has been made on some 44 "Case Studies" of retrofits performed in school buildings and systems in U.K. and Italy.

The survey has been made by means of forms, specially prepared for this ANNEX XV action, as reported in Fig. 11.

Only essential data has been reported: country, name and address of the school, type of measure taken, short description of installation.

For every measure, savings are given as a percentage of previous energy consumption, or in terms of amount of fuel saved. Some indications of the payback time are also given.

For an economical and financial evaluation, payback figures of under one year are very good; those between one and five years are generally considered acceptable; and those greater than five, marginal.

All measures which have been considered in this survey have been divided in nine major items, as follows:

1. substitution and repair of window frames, applicaton of double glazing;
2. insulation of roofs, walls, basements, false ceilings, etc.;
3. control systems, monitoring systems, thermostatic radiator 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 and 2 refer to actions made on the building, while all other 7 items refer to actions made on systems and their components (mechanical, electrical, swimming pools, kitchen, etc.).

A detailed report, which can be found in the Appendix, has been produced, which shows a complete analysis of the Case Studies. A copy of the form for all cases is also attached.

A summary table has been compiled, showing how many times the nine energy saving measures have been used in the 44 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.

4. SEMINARS

Six Seminars were organized on special topics, three in U.K. and three in Italy, with large participation of experts, consultants, manufacturers, contractors, teachers, school administrators and school authorities.

For each seminar, a report has been prepared, with the titles of all papers presented, a summary of the topics and of the discussion, an indication of the most significant problems and results.

The six reports may be found in the Appendix to this Final Report.

Title and subject of the six seminars are the following.

Building Energy Management Systems: Milan, April 21, 1989

A Seminar on *B.E.M.S.* was organized by Italy with presentation of 13 main reports: 8 reports from manufacturers and 5 from users who reported the experience as operators of B.E.M.S.; 2 reports were from Britain, 11 from Italy.

The proceedings of the Seminar have been published, with all reports presented and a summary of the discussion.

Passive Solar Design: Cambridge, May 31, 1989

A Seminar on "Passive Solar Design in Schools" was organized by U.K. Working Group of Annex XV.

Eight papers were presented, with two from Italy and one from W. Germany.

Passive Solar design in its most basic form is to utilize free heat and light when required and available, but provide protection against overheating.

As a conclusion of this seminar, there is a potential use of passive solar energy in schools buildings, more in U.K. than in Italy.

All reports presented in this seminar have been published in the "International Journal of Ambient Energy" Volume 11, Number 1, January 1990.

Energy Retrofitting in Schools: Rome, October 26, 1989

A seminar on "Energy Retrofitting in Schools" took place in Rome, organized by Italy, with presentation of 20 reports; 2 of them were from U.K., one from W. Germany.

Many examples of retrofitting actions performed in schools have been presented and discussed, demonstrating the potential for energy saving associated with such measures.

The proceedings of the seminar with all papers presented have been published and are available.

Energy in Educational Field: Puckeridge (Herts) May 2, 1990

This Seminar, organized by U.K., was directed towards Headteachers and School Governors, with the aim to demonstrate the need for energy saving, 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 between professional energy management in schools and the curriculum requirements for energy education was highlighted.

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

Six technical papers were presented.

Management and Maintenance in Schools: Rome, September 26, 1990

The fifth Seminar, on "Management and Maintenance in Schools, with their contractual aspects" was held in Rome, with presentation of 12 reports: one was from U.K.

The importance of a good design was pointed out, with consideration of the linkage between internal conditions, environment conditions, efficiency of the system, fuel consumption, pollution.

Maintenance of schools is expensive: but it is important to realize that failure to maintain is even more expensive.

The proceedings of the seminar, with the text of all reports presented, will be published, and the book will be available by mid 1991.

Electricity Economy in Schools: Cambridge, October 10, 1990

This Seminar was organized with the intention to assist Headteachers, Bursars and Governors, who are now responsible in U.K., under local Management of Schools, for their school electricity budget, as well as the local Authorities' central decision makers and designers.

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 in schools has received relatively little attention.

An increase in electricity cost per pupil, by 14% between 1978 and 1985, has been recorded in U.K.

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

Five reports were presented.

5. RETROFITTING

Retrofit is defined as a modification of equipment to incorporate changes made in later production of similar equipment, and applies to building as well as to any kind of system.

It has already been shown that owing to the decline in school population the construction of new schools has been greatly reduced, both in U.K. and Italy.

Therefore the interest and consequent programs for energy conservation measures should be directed more to existing buildings than to new ones, i.e. more to *retrofitting* than to *design*.

An effective energy management program should always include the investment of financial, as well as, human resources. While significant energy conservation may be effected by sound management and maintenance practice, certain programs may require investing in retrofits to existing or in new technologies.

Based on the results of "Case Studies" analysis, and on information collected in the Seminars and in the meetings during the development of work of ANNEX XV, the energy conservation measures generally adopted in existing schools are reported here.

5.1 Assessment of the performance of the building

Energy consumption in most existing schools can be reduced without adversely affecting the comfort of the occupants.

The most appropriate techniques for doing this will vary from building to building, depending on the method of construction and the physical condition of the structure and the associated systems.

Techniques are available for assessing the thermal performance of buildings; nature of the building fabric, heating and electric system, swimming pool, etc and their chief deficiencies in terms of energy consumption.

I.E.A. ANNEX XI "*Energy Auditing*" produced "Source Book for Energy Auditors", Volumes 1&2, which provide much useful information as well as an audit methodology and would be of assistance to those interested in energy analysis.

5.2 Substitution and repair of window frames, applicaton of double glazing

According to the results of "Case Studies" analysis made by Annex XV, approximately 6% of such cases involve substitution of existing windows with new double glazing, generally with substitution of frames.

It must be pointed out that double glazing alone cannot be considered a cost effective measure unless windows have to be replaced. Under these circumstances the payback is likely to be in excess of 12 years.

An interesting action is the reduction of glazed areas, which has been carried out sometimes in older schools, with the aim to reduce heat losses.

5.3 Insulation of roofs, walls, etc

As previously indicated in § 2.5 the standard of thermal insulation (the "U" value) for roofs and solid external walls currently specified for new building, is $0.6\ W/m^2 \cdot K$ in U.K., and a similar figure in ITALY.

The "U" values currently accepted some years ago, when fuel costs were lower, were rarely better than 1.0 to 1.1 W/m^2·K, and many older school building are today well below modern standards of insulation.

To improve walls and roofs, employing suitable insulating materials, "U" values of below 0.5 W/m^2·K are sometimes readily achievable and cost effective.

In most cases it will be difficult, if not impossible, to add insulation to the existing structures.

However, such improvements have been extensively carried out in many school buildings, as shown in some of the actual case studies considered in chapter 3.

Insulation methods generally used include the following:

- applicaton of insulating panels on internal side of walls and roofs;
- spray-on polyurethane foams;
- injection of a suitable expanding foam in the cavity between internal and external walls.

Payback is rarely less than 6 to 8 years, depending on the previous conditions of the structure.

5.4 Control system

Temperature controls play an important role in the school's energy consuming systems.

A single thermostat maladjusted or out of calibration can cause unnecessary heating or cooling, resulting in excessive energy consumption.

5.4.1 Heating compensation

The most common system for temperature control is heating compensation, in which the heating system flow temperature is adjusted inversely with outside air temperature within defined limits. This system operates by means of a three-way modulating valve, controlled by sensors of external temperature, flow water temperature, electronic devices and actuators.

The cost of this type of control system is low, and a payback of 2½ to 3 years is generally recorded.

5.4.2 Optimizer

To prevent useless waste of energy, it is important that the building reaches operating temperature just prior to occupancy.

Electronic devices known as "optimum start controllers" have been developed, which, when fed with data related to internal and external temperature, compute the optimum time to start the heating system for the day and switch on the boilers, circulating pumps and other components of the system.

5.4.3 Frost Protection

It is necessary to minimize the amount of heating required when the school building is not in use: night-time, week-ends, holidays, etc. A considerable amount of energy is wasted in educational buildings in the winter because frost protection thermostats operate at too high a temperture.

Simple automatic controls should be put in place, and regularly checked; an external frost-stat setting of 2 °C should be suitable for most school building but this will depend on the local situation.

5.4.4 Thermostatic Radiator Valves

Another method of heating control is to install thermostatic radiator valves.

These valves modulate the output of radiators to accomodate heat inputs from other sources, such as solar gains and occupants, and maintain a stable room temperature.

Valves with remote sensors are preferable.

5.4.5 Building Energy Management Systems

In larger buildings it is often convenient to link the heating plant controls to a Building Energy Management System (BEMS).

BEMS are used to minimize energy use, improve comfort levels and optimize the efficiency of the plant by monitoring, recording and controlling a number of building's energy services.

The remote monitoring and control of these services enables a higher standard of operation and maintenance to be maintained whilst providing information on energy flows, consumption, performance of equipment, and trends.

It is usefuel to recall that in the same I.E.A. Programme "Energy Conservation in Buildings and Community Systems" two other Annexes are studyng the problems related to the efficient use of these equipment, namely Annex XVI, "BEMS 1" and Annex XVII, "BEMS 2"

5.5 Improving boiler operation

Boilers are the main users of energy in a School Building, and require care and attention, in order to be properly used.

Improving existing boiler's performance may be obtained by means of several energy conservation actions such as the following.

5.5.1 Dampers

Installation of dampers on flue gas ducts, manually or automatically operated, to cut boiler ventilation when not firing, reduces heat losses. Savings of energy may be in the range of 1 to 2%, depending on the size and number of boilers, type of fuel, etc., with low installation cost.

5.5.2 Sequence control systems

Installation of sequence control for a multiple boiler system has proven reliable and cost effective.

Sequence procedure allows correct firing of boilers as heat demand rises and avoids, for example, having more than one boiler running at less than full load.

The boilers are switched on and off as required to match the changing heating load, with the lead boiler changed periodically.

With unit power of boilers in the range of 200-300 kW, the savings obtained with this measure may be in the order of 5 to 8%.

5.5.3 Use of an alternate fuel

The trend, in U.K. and Italy, is to convert heating system from fuel oil to natural gas.

Natural gas permits a better combustion control with an increase in efficiency. The energy benefits of this operation are in the range of 3 to 5%, but the economic results depend on many other factors, difficult to appreciate, which require a detailed analysis for every case: cost of oil and of gas, cost of installation, time of operation, size of the boiler, seasonal combustion efficiency of the equipment, etc.

5.6 Replacement of boilers

The complete replacement of the boiler (s) may be found necessary due to many factors, such as:

- age and conditions of existing boilers;
- changes in the heat load of the school;
- major changes or alterations of building and associate systems;
- others.

Boiler replacement is often undertaken as a part of a wider package of refurbishment measures which may include alteration of structure and architecture of schools, reduction or increasing of the number of classrooms and pupils, review of school services, etc.

In such instances, the opportunity to replace one large boiler with a number of smaller units, should be considered.

5.7 Insulation of pipe, tanks, etc.

The thermal insulation of heat storage tanks and of the heat distribution pipes can be improved in many cases, and the cost of this operation may be recouped in fuel savings in a short while.

The insulation of hot pipes is one of the most cost effective energy conservation measures.

5.7.1 Insulation of valves and fittings

When steam or high temperature pressure water is employed as a heat carrier, it is always effective to insulate not only pipes and collectors, but also the valves and flanged couplings.

The heat losses associated with such components may be easily calculated by means of the equivalent length of an uninsulated pipe of the same diameter:

- flanged valves: equivalent length 1.8 m
- flanged coupling: equivalent length 1.2 m

This energy conservation measure is very cost effective, with a payback of 1 to 2 years, in the case of a high temperature medium.

5.8 Energy Conservation Measures in Boiler House Systems

Boiler house systems offer interesting opportunities to take measures which may reduce significantly energy consumption.

5.8.1 Separate D.H.W System

Production of D.H.W. is very often carried-out using the same boilers as the heating system, whose size is normally too large for an economical summer operation.

Retaining the central production system, the efficiency may be substantially increased by installing a smaller boiler, dedicated to D.H.W. production.

This measure has proved to be cost effective, with a saving of 2 to 5% depending on the size of the school, existence of swiming pool, kitchen, etc.

5.8.2 Temperature of D.H.W.

Thermostats controlling domestic hot water should be set to give the lowest acceptable temperature which should never exceed values indicated in § 2.8; where warmer water is needed, for example in dishwashers, local "topping up" or a separate supply should be considered.

5.8.3 Decentralized production of D.H.W.

The efficiency with which hot water is provided within school buildings may be improved, by decentralizing the system, and introducing point-of-use hot water appliances.

In other cases it was demonstrated to be cost effective to shut down the burner of the boiler during the summer and install an electric boiler for D.H.W. production.

5.8.4 Zone controlling

Zone heating is appropriate when separate zones of a building can be heated independently. The allocation of rooms for day time and any evening use should be made so that the plant is used economically, and heat and light are not supplied to unused areas.

Zone control should also take into account the orientation of the building and the activity within it.

Application of zone control is possible only when suitable pipework is in place, with separate loops for each zone.

5.9 Solar energy

As is well known, solar energy is the energy transmitted from the sun in the form of electromagnetic radiation. The sun's energy reaching the Earth is immediately available as light and short wave radiation and is converted to heat on striking any surface.

Solar heating may be used by means of two different technologies:

- ***passive solar heating***: involves architectural solutions, orientation of the building, arrangement of glazed areas, optimum insulation of walls and roofs, etc.

- ***active solar heating***: employs mechanical devices and equipment, designed to convert solar radiation into heat, and to transfer it to the building.

There is a third option, "***hybrid solar heating***", which is a combination of the first two.

5.9.1 Roof space collectors

A roof-space solar-energy collector is essentially a pitched roof which is partially or fully-glazed on its southerly aspect. The roof space collectors pre-heat the ambient air before it is conveyed to the auxiliary gas-fired warm-air space heating system.

When this measure forms an integral part of a new building, the initial capital cost is low; saving in running cost may be considered in the range of 10 to 15% of the total cost of the fuel for the heating system.

5.9.2 Solar collectors

The solar collector is any panel, pipe or target that collects radiation from the sun, converts it into heat, transfers the heat to a suitable heat carrier (air, water, oil, ...) and finally delivers the useful heat to the user (space heating, hot water, etc.).

Solar collectors have gained wide attention in the years following the start of the energy crisis, 1973, and many examples exist, both for space heating and for D.H.W. systems.

Today interest is considerably reduced, and demonstration projects are limited to flat collectors, for D.H.W. production.

Payback is long, not less than 8 to 10 years, owing to high initial costs, which must include structural components, mechanical and electrical systems.

5.10 Heat pump

The programs for attaining substantial reduction in national energy consumption require the progressive introduction of more energy-efficient equipment, with innovative and novel technologies, one of which is likely to be a heat pump.

A heat pump is a machine that uses a refrigeration cycle to extract heat from a heat source at a low temperature and upgrade it to a higher, more useful temperature. Power must be used to drive the heat pump's compressor and evaporator/condenser fans.

The amount of energy in the heat discharged from the heat pump is generally several times greater than the power consumed, particularly if the temperature rise from the source to the sink is small.

Heat pumps offer considerable scope for improving the efficiency of energy use wherever heat is required at temperatures below 100 °C: they can greatly improve energy efficiency in building heating with the assumption that this technology be successfully developed to the point of widespread application in economic competition with other options.

The practical application of this technology is at a level of a few per cent of the market potential, and it is apparent that substantial barriers to investment in energy-efficient equipment of this type still remain.

As for school application, the use of heat pumps, today, seems limited to indoor swimming pools. In particular, the ventilation extract air from an indoor pool is a plentiful heat source at a temperature only a few degrees below that at which useful heat is required for the pool water and the pool hall.

In U.K., heat pumps have been installed in at least 20% of all indoor swimming pools.

The cost effectiveness evaluation of a heat pump system requires a detailed design with cost analysis.

5.11 Lighting and Electric system

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.

The reduction of electric demand will also have beneficial effects on environment, as a considerable portion of electricity is produced by fossil-fuel generating stations. Improving the efficiency of lighting systems will contribute to the reduction of greenhouse gas emissions.

Each room or other space should have lighting appropriate to the normal use for which it is designed.

The lowest level of maintained illumination, whether daylight or electric light, at any point on the working plan, should be not less than 150 lux.

5.11.1 Size of windows

It has been shown (§ 5.2) that sometimes it is convenient to reduce the size of windows, specially in old buildings, with the aim of reducing the thermal energy consumption.

It must be pointed out that the reduced heat loss may be offset by the increased use of electric lighting.

Taking into account educational and human needs, the balance between daylighting requirements and electric lighting costs, heat loss and solar gain, taken together, is usually struck with a glazed area equivalent to 18% to 23% of the floor area for a space 5 m deep.

5.11.2 Lamps replacement

The replacement of tungsten lamps with other, more efficient forms of lighting permits a sizable reduction in energy consumption. Fluorescent lamps are about four times more efficient than filament lamps.

This measure has proved to be cost effective, with a payback in the order of less than two years.

5.11.3 Position of luminaires

Reorganization of the position of luminaires, with a review of the position of switches, encourages economic use of electric lighting.

5.11.4 Switching and controls

The purpose of controls is to see that lighting is provided in the right amount, in the right place, for the required time.

Lighting automatic control is another way to reduce energy consumption, with different forms:

- time controls;
- photo-electric controls;
- occupancy sensors.

This measure in generally not cost effective if rewiring has to be undertaken specifically for such controls. A detailed calculation should be made to show the expected level of savings from reduced hours of use.

6. ENERGY IN EDUCATIONAL FIELD

One of most important and interesting activities of ANNEX XV, in collecting information, data, and experience on "Energy Efficiency in Schools" has been to explore the inside world of the school, to seek and to understand whether this world could be involved and help to attain the imperative objective of reducing energy consumption.

Energy is becoming a subject on the curriculum at most schools; here is a good opportunity to demonstrate good practice in energy conservation in the same buildings in which these studies are undertaken.

The school is indeed the best place to lay the ground work for a new wave of energy consciousness, keeping in mind the linkage between Energy, Economy, Environment, Education.

Not only do schools represent a significant potential for savings in the national energy requirements but they are also in a unique position to demonstrate energy awareness in the education of children. By doing this we are ensuring that future generations will come to regard energy as a valuable and important resource.

A seminar on "Energy in the Educational Field" was held in PUCKERIDGE (Herts) on 2 May 1990, 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 results and main conclusion of this seminar may be found in the report in the Appendix.

In Italy, teaching energy conservation basic concepts in schools is being investigated by ENEL (Italian National Electric Energy Generating Board) with their engineers in cooperation with school teachers.

An agreement has been recently signed by Ministry of Education and ENEA (Italian National Board for the development of Alternative Energies) for a joint program for the Energy in School.

In the U.K., as shown both from Seminars and from the available literature, a much wider interest exists on a national level, and an extensive programme of work in this field is underway.

As an example, the Department of Energy has produced a set of booklets which constitute the "Energy in Primary Science Pack"; this pack is mainly intended for LEA organizers wishing to conduct the study of energy with teachers responsible for primary science, but it will also be a useful resource for those engaged in initial teacher education.

The pack, besides an introduction, glossary and bibliography, which provides a background to the units, is made up of 8 units, as follows:

Units 1 & 2:	Mechanical Energy and Sound
Unit 3:	Magnetism and electricity
Unit 4:	Chemical energy, food, fuels
Unit 5:	Light
Unit 6:	Heat
Unit 7:	Sources and resources
Unit 8:	Energy and environment

The materials are presented as a flexible source and resource pack, not as a prescribed course.

They include teachers' Notes giving background information and wherever possible, a number of straightforward practical activities for pupils.

The pack is intended to support teachers in developing ideas about energy. To that end the materials focus upon the knowledge, skills and attitudes involved in scientific inquiry.

A considerable number of children activities are suggested as a practical contribution to that support. Many of these practical activities should concern the mechanical and electrical systems and the building of the school itself, check-out of operating conditions, monitoring of the energy utilized and lost, environment conditions, etc.

In other words, most of the operations which are considered in the frame of "Maintenance", chapter 7, may be performed by the students, as their practical activity.

In carrying out these actions, school personnel and students are actively involving themselves in the economic and efficient operation of their own school as well as placing themselves in the best position to provide information on required maintenance work.

This could be one of most interesting aspects of the matter, because it gives the pupils, probably for the first time, the possibility to "see" the components of a working system, and to understand the meaning of one of the definition of energy: "Energy is what makes things happen".

7. MAINTENANCE

A substantial portion of energy costs in schools can result from improper operation and maintenance of the building and its systems; experience has shown that much can be done to conserve energy by good housekeeping and careful maintenance.

Education authorities themselves can help to conserve energy by ensuring that school and caretaking staff are made aware of fuel economy measures, and when necessary are given suitable instructions. Most of the energy savings can be achieved with an increased awareness of where and when energy is being wasted.

Qualified technical staff and experts are generally not present or available in schools: therefore teaching staff, pupils, caretakers and anyone using the school building should have the responsibility to take simple good housekeeping measures.

A number of typical Energy Management opportunities, are outlined in this section. This is not a complete listing of the opportunities available: however, it is intended to provide ideas for management, operating and maintenance personnel to identify opportunities that are applicable to a particular facility.

Valuable savings may be achieved by carrying out simple steps shown here. Many of these measures cost nothing to implement and can do much to enhance the conditions in which the school's staff and pupils work.

As reported in chapter 6, many actions may be performed by the students themselves, as a part of their practical activities.

It must be pointed out that nobody but the authorized personnel who have the responsibility of the management and maintenance should be allowed to take any direct action on the systems and to "touch" the components.

Students may only "see" instruments, operate switches, faucets, doors, etc, take note of any malfunctions, and refer to teachers, in order to let the message be sent to responsible operators. When the correct operation is restored they will repeat the readings in order to check if the repairs have been properly performed.

7.1 Building envelope

Weaknesses or faults in the envelope can cause excessive thermal transmission losses, unnecessary infiltration or exfiltration and ineffective solar gain. Energy losses can be reduced by improved maintenance procedures.

- Check the weatherstripping and caulking on all entrance doors and openable windows.
- External doors should be kept closed as much as possible, and windows should be shut at night.
- Periodical checks should be made to see that thermal insulation is in good condition and dry, mainly in areas where there is high incidence of condensation.
- Ensure that outside and inside doors which separate areas of different ambient conditions are closed. Eliminate door stops on self-closing doors between areas of different conditions.
- Adjust door hardware to ensure smooth, quick and complete closure.
- Adjust or replace window hardware to eliminate unwanted air movement through the building skin.
- Operate window shading devices properly, i.e., close drapes and blinds during summer months and open them during winter months when exposed to direct sunlight.

7.2 Heating system

Check that all necessary instruments are in place and properly operating: thermometers for water temperature in all points of the several systems and loops, flue gas temperature, air temperature in all air systems; pressure gauges; level controller; fuel consumption meters; electricity meters.

Ensure all people involved in the maintenance of air or water systems understand the functions of various temperature control systems. A general understanding of the operation of the systems will help identify problems when they occur and enable corrective action to be taken promptly.

- In steam systems, check condensate tank vents for visible plume of steam which indicates leaking traps.
- Ensure that pipe and duct insulation is continuous and in good condition. Poor insulation continuity causes uncontrolled energy losses to the surrounding environment.
- Temperature controls play an important part in the school's energy consumption. To determine whether or not control systems are operating properly, take regularly ambient temperature in all classrooms, offices, service rooms, etc, taking also in the same moment the external temperature and the flow hot water temperature from the boiler.

  A team of students may successfully perform this operation, which must be repeated several time in one winter month, with different external conditions; then compile a table with all figures, thus permitting to check if the distribution of temperature is uniform throughout the school building, and if ambient temperatures fit specifications. It is also possibile to plot actual hot water flow temperature vs. external temperature and compare with the theoretical design curve of the system, which must be provided by the firm who is charged for management and maintenance. If these temperatures are recorded regularly, it will be easier to identify the operating sequences of the temperature control system.

7.3 Hot water system

- Check the temperature setpoints on water storage tanks on a regular basis to ensure there has been no tampering.
- Inspect the faucets at all sinks including lavatories, janitors' closets and kitchens to ensure that the valves close drip tight. Attend to faucets which do not shut off completely.
- Clean strainers and drain water storage tanks on a regular basis to reduce pressure drops through piping systems.
- Check if the time clock to shut down the recirculation pumps during unoccupied hours is properly operating. This will not only reduce the electrical energy input to the system, but will also reduce the thermal losses in the hot water piping system.

7.4 Electric system

- Switch off toilet extraction fans in off hours; this will reduce not only the electricity consumption, but will also prevent wasteful extraction of warm air.
- 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 maximum demand charges are applied.

8. CONCLUSION

The work performed by ANNEX XV Working Group, summarized in this Final Report, with results and data drawn from seminars, meetings, examination of documents, discussion, leads to the conclusion that Schools offer a very interesting ground for application of general and established rules of energy savings, with the aim to attain substantial reductions in energy consumption; savings may be achieved in four main ways:

1. Altering the physical construction of a building to reduce its heat loss characteristics;
2. Replacing or upgrading the energy consuming equipment and controls to make it more efficient;
3. Changing or modifying energy consuming equipment to use a less expensive form of energy or more advantageous tariff;
4. Continuous assessment of consumption.

8.1 Reduce building heat loss characteristics

This aspect of the problem concerns retrofit actions on the building. According to the available data, such actions generally require high investment costs with long payback.

8.2 Actions on systems and equipment

This is probably the most promising option, and concerns areas where various energy saving measures or retrofits might be successfully applied on the various systems. Many of these measures are simple and low cost, and can be implemented by the school or by maintenance personnel. Others, including the complete replacement of equipment and systems, are more expensive and complex, and qualified professional should be consulted.

Generally these kind of actions are cost effective, with acceptable payback.

8.3 Changing form of energy

This kind of retrofit may be very important and leads to considerable savings, provided that a cost/benefits analysis has been made, with promising results.

Changing the form of energy implies extended retrofits in the heat generation system, and requires a parallel analysis of the tariffs and cost for fuel, electricity, labour.

8.4 Continuous assessment of consumption

This can be used to check that both the plant and the equipment continue to operate as intended, and also to ensure that the occupants behaviour is not adversely affecting energy use.

This is often known as good housekeeping, and includes also all actions for management, maintenance and monitoring.

The extent to which energy saving can be achieved is largely determined by the attitude of the energy user.

Appropriate training will provide staff with an awareness of the importance of energy efficiency and equip them with the expertise to put into practice.

8.5 Monitoring

Monitoring plays a key role in the evaluation of a successful energy conservation program. Without monitoring there is no yardstick by which to judge the success of the program.

To develop an effective monitoring schedule, it is necessary to acquire energy bills from the last year or two. The consumption (and demand) figures from these bills should be transferred to a master form for record-keeping purposes, including all energy bills from each source and tabulate them monthly.

This will provide a strong basis for comparison of consumption before and after the implementation of energy conservation measures.

In some cases, in may be advisable to take daily or hourly meter readings of energy consumption to establish the load profile immediately before and after an energy conservation retrofit.

An additional benefit of record keeping is that easily overlooked problems can be identified quickly by regular inspection of the records.

When new readings are entered, they should immediately be compared to the figures from previous years. For instance, an unusual increase in natural gas consumption may indicate that a fresh air damper is sticking, or temperature set points have been tampered with.

Emphasis must be placed not only on keeping records active and updated, but also on maintaining a regular analysis of the values entered. In this way record-keeping evaluates the progress of the energy conservation program, highlights problem areas and acts as a comparison base with other schools and programs. Record keeping should be intended to fulfill a purpose, not merely fill a form with numbers.

All the actions recommended under "monitoring" could be performed in the framework of "Energy in Curriculum".

9. RECOMMENDATIONS

The work of the Annex has clearly shown that the "education" sector is a major user of energy. Although some attempts are underway to reduce energy consumption in shools, there is still a lot of scope for further savings. I.E.A. members may wish to launch national and local programmes based on the findings mentioned in the report. Reductions of about 20% in energy consumption can be achieved over 5-10 years, relatively easily. Savings on energy expenditure could provide extra funds for other educational activities like purchase of books and computers. Hence it is important that the education authorities continue with this work.

In this respect I.E.A. ANNEX XV provided and important forum for exchange of ideas and gave participants an opportunity to learn from experiences of other countries. It is therefore recommended that the ANNEX should continue with a new work plan and with more countries joining in. It would also be helpful if further and higher education establishments can be included so that the whole education sector is covered. Energy efficiency in education is not just about saving money but about a better learning environment and educating citizens of tomorrow in the economic use of our energy resources.

U K			ITALY		
- SURFACE	km^2	244,000	- SURFACE	km^2	301,000
- POPULATION		57,000,000	- POPULATION		56,000,000
- NUMBER OF PUPILS		8,000,000	- NUMBER OF PUPILS		8,650,000

Fig. 1 - General data for U.K. and ITALY

Fig. 2 - Comparison of maps of U.K. and ITALY
- U.K.
- ITALY

		°C	°C
1 -	Dundee	8.5	2.6
2 -	Edimburgh	8.6	3.1
3 -	Glasgow	8.9	3.1
4 -	Manchester	9.3	3.3
5 -	Birmingham	9.5	3.3
6 -	London	10.7	4.1
7 -	Cardiff	10.1	4.1
8 -	Plymouth	10.7	5.9
9 -	Southampton	10.7	4.5

		°C	°C
1 -	Torino	11.2	1.8
2 -	Milano	12.8	0.5
3 -	Venezia	12.9	2.4
4 -	Genova	16.1	7.5
5 -	Firenze	14.4	5.7
6 -	Roma	15.4	7.5
7 -	Napoli	16.9	9.0
8 -	Bari	15.7	8.8
9 -	Palermo	19.1	12.2
10 -	Cagliari	16.9	9.3

Fig. 3 - Comparison of climate conditions in some towns in U.K. and ITALY

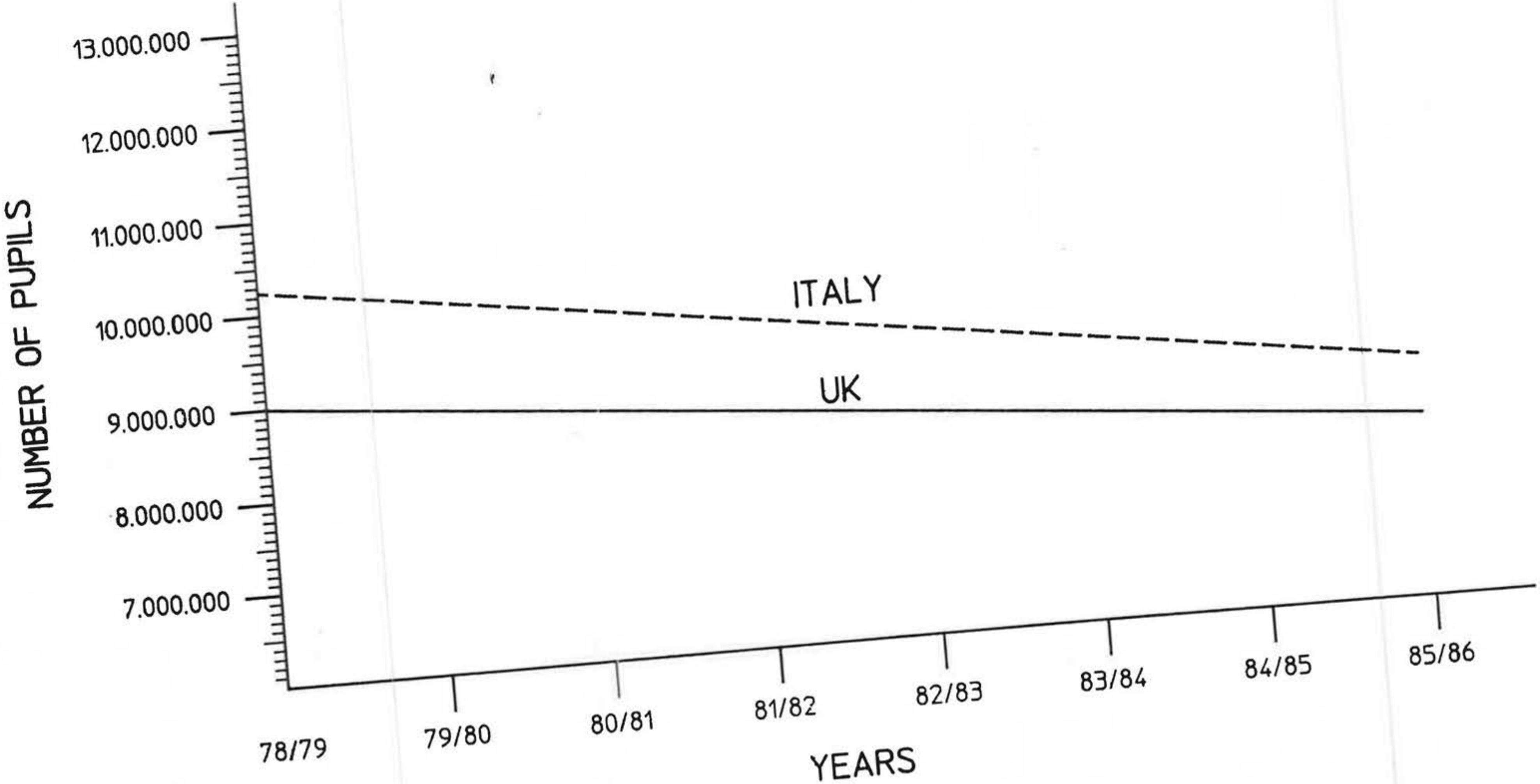

Fig. 4 - Variation of the number of Pupils in U.K. and ITALY

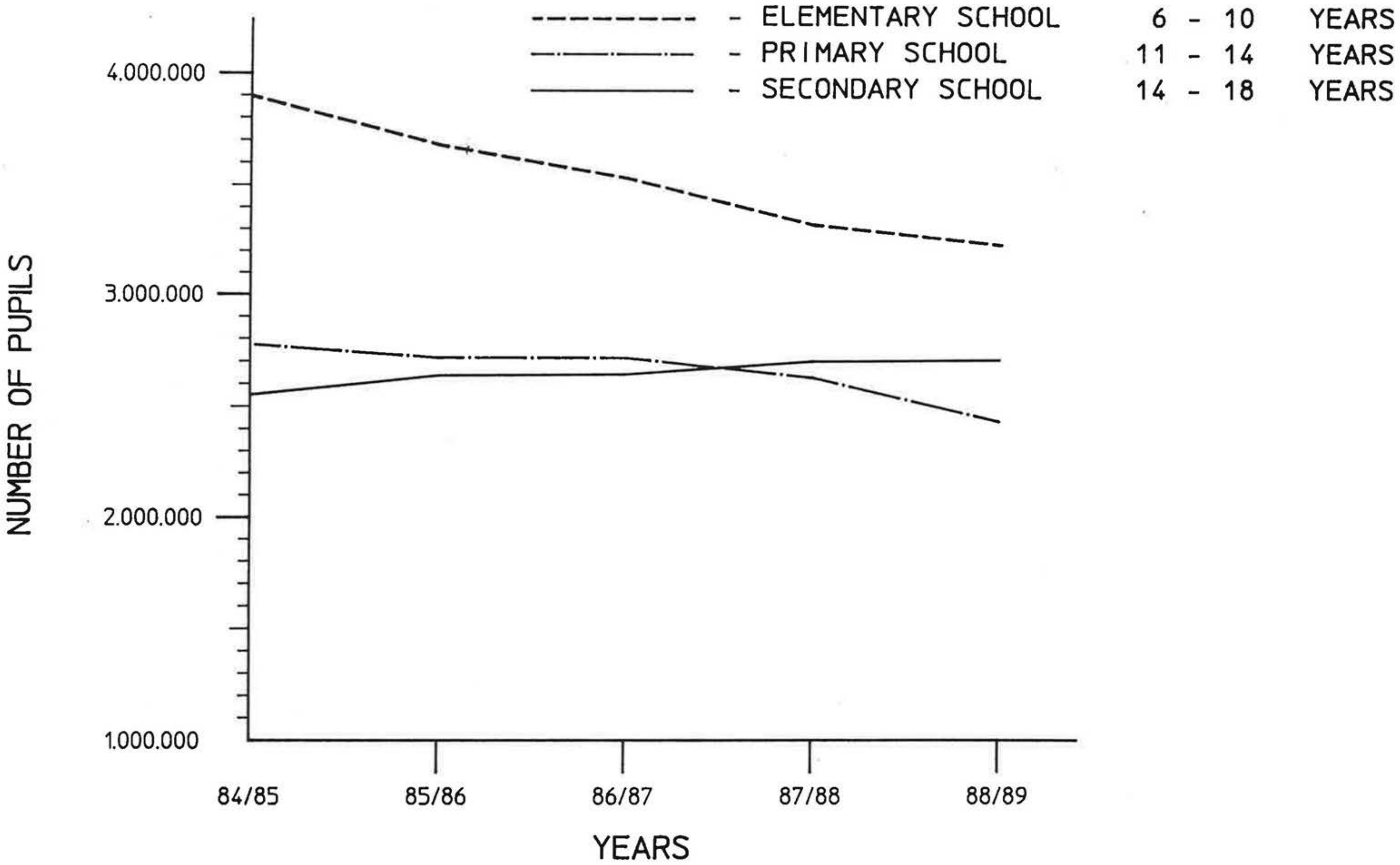

Fig. 5 - Variation of the number of Pupils in ITALY considering various types of Schools

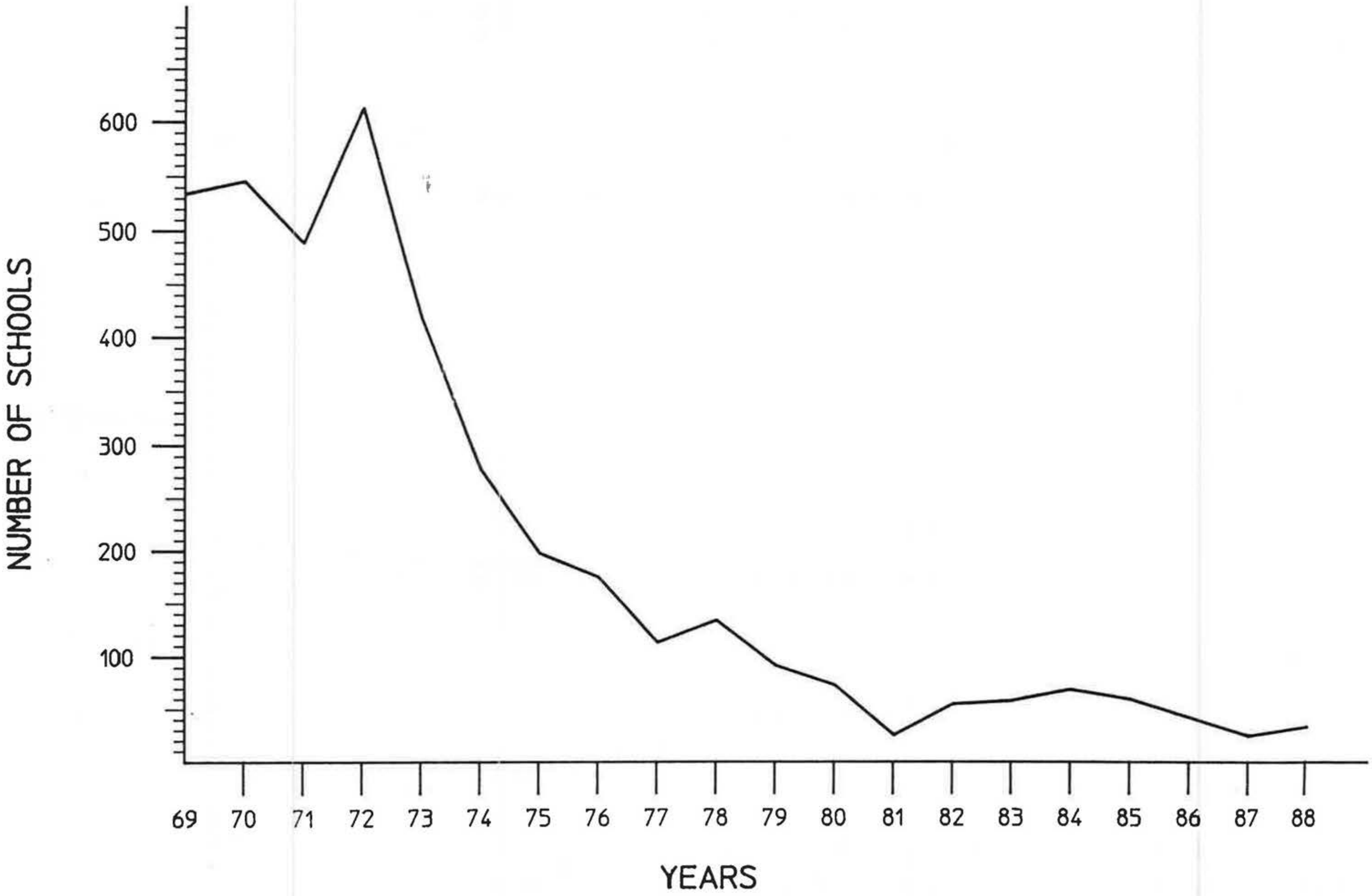

Fig. 6 - Number of new schools built in U.K.

Form nº 1 - 20 April 1989

IEA ANNEX XV

ENERGY EFFICIENCY IN SCHOOLS

ENVIRONMENTAL STANDARDS FOR SCHOOLS

COUNTRY: .________________.

YEAR: 19___.

TYPE OF SCHOOL: .________________.

WINTER EXTERNAL DESIGN TEMPERATURE: see Form nº 2

WINTER INTERNAL DESIGN TEMPERATURES:

- CLASSROOMS ________ °C
- CIRCULATION AREAS ________ °C
- DORMITORIES ________ °C
- GYMNASIUMS ________ °C
- MEDICAL ________ °C
- .... ________ °C
- .... ________ °C

DESIGN VENTILATION REQUIREMENT:

- AIR PER PERSON PER HOUR: ________ $m^3/h \cdot pupil$
- AIR CHANGES PER HOUR: ________ 1/h
- .... ________ ......

GLAZING AREA ON:

- EXTERNAL ELEVATION ________ %
- ROOF ________ %

MAX-U-VALUES:

- WALLS ________ $W/m^2 \cdot K$
- ROOF ________ $W/m^2 \cdot K$
- WINDOWS ________ $W/m^2 \cdot K$
- FLOOR ________ $W/m^2 \cdot K$

Fig. 7

DAYLIGHT FACTOR: ________ %

ARTIFICIAL LIGHTING LEVEL:

- CLASSROOMS	________	lx
- CIRCULATION AREAS	________	lx
- SPORT AREAS	________	lx
- WORKSHOPS	________	lx
- MEDICAL	________	lx
-	________	lx
-	________	lx

ARE THERE ANY ENERGY TARGETS? ________ YES/NO

IF "YES", WHICH TARGETS?

ARE THERE ANY ENERGY REQUIREMENTS? ________ YES/NO

IF "YES", WHICH REQUIREMENTS?

COMMENTS:

Form nº 2 - 20 April 1989

IEA ANNEX XV

ENERGY EFFICIENCY IN SCHOOLS

STATISTICAL DATA OF ENERGY CONSUMPTION

COUNTRY: .______________________________.

YEAR: 19____.

SCHOOL DAYS (total): .____________.

SCHOOL DAYS IN THE HEATING SEASON: .____________.

MEAN LENGTH OF SCHOOL DAY (hours): .____________.

Ext. Design Temp.(°C)	Degree Days (K·d)	% total [1]
	< 1000	
	1000 ÷ 2000	
	2000 ÷ 3000	
	3000 ÷ 4000	
	> 4000	
Base temperature for calculating D.D. : °C.		

	Type of School		
	PRIMARY [2]	MIDDLE	SECONDARY
Age of pupils			
Nº of Schools			
Nº of Pupils			

[1] Percentage of the total number of schools

[2] Nursery included

Fig. 8

TOTAL ENERGY CONSUMPTION

ELECTRICITY:		______________	TJ/a
FUEL:	- TOTAL	______________	TJ/a
	- GAS	______________	TJ/a
	- OIL	______________	TJ/a
	- COAL	______________	TJ/a
	- OTHER	______________	TJ/a

	Type of School		
ENERGY FORM	**PRIMARY**	**MIDDLE**	**SECONDARY**
Electrical ($MJ/m^2 \cdot a$)			
Electrical ($MJ/pup. \cdot a$)			
Heating ($MJ/m^2 \cdot a$)			
Heating ($MJ/m^3 \cdot a$)			
Heating ($MJ/pup. \cdot a$)			

COMMENTS:

Thermal energy consumption

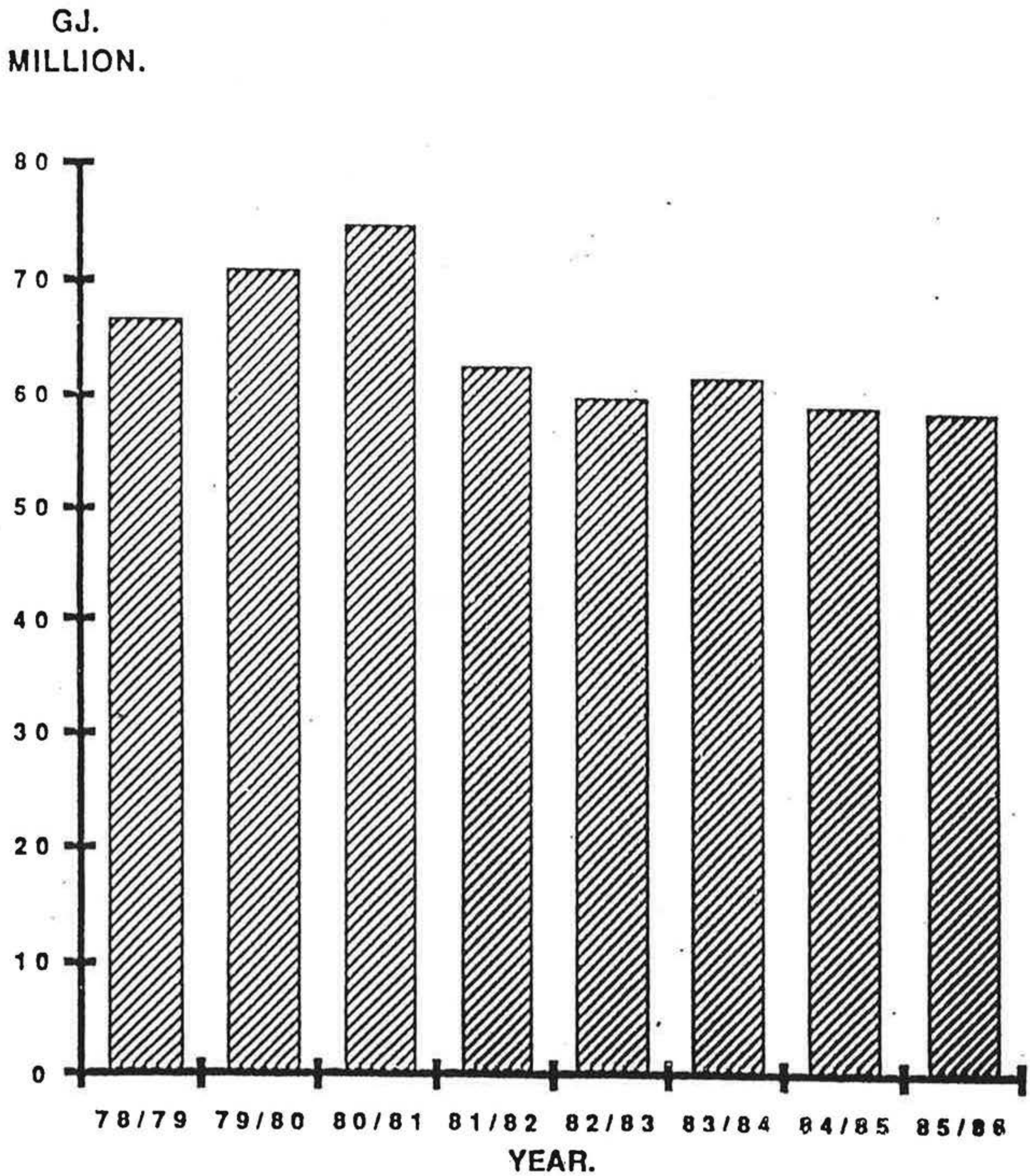

Fig. 9- Thermal Energy Consumption in Schools in U.K.

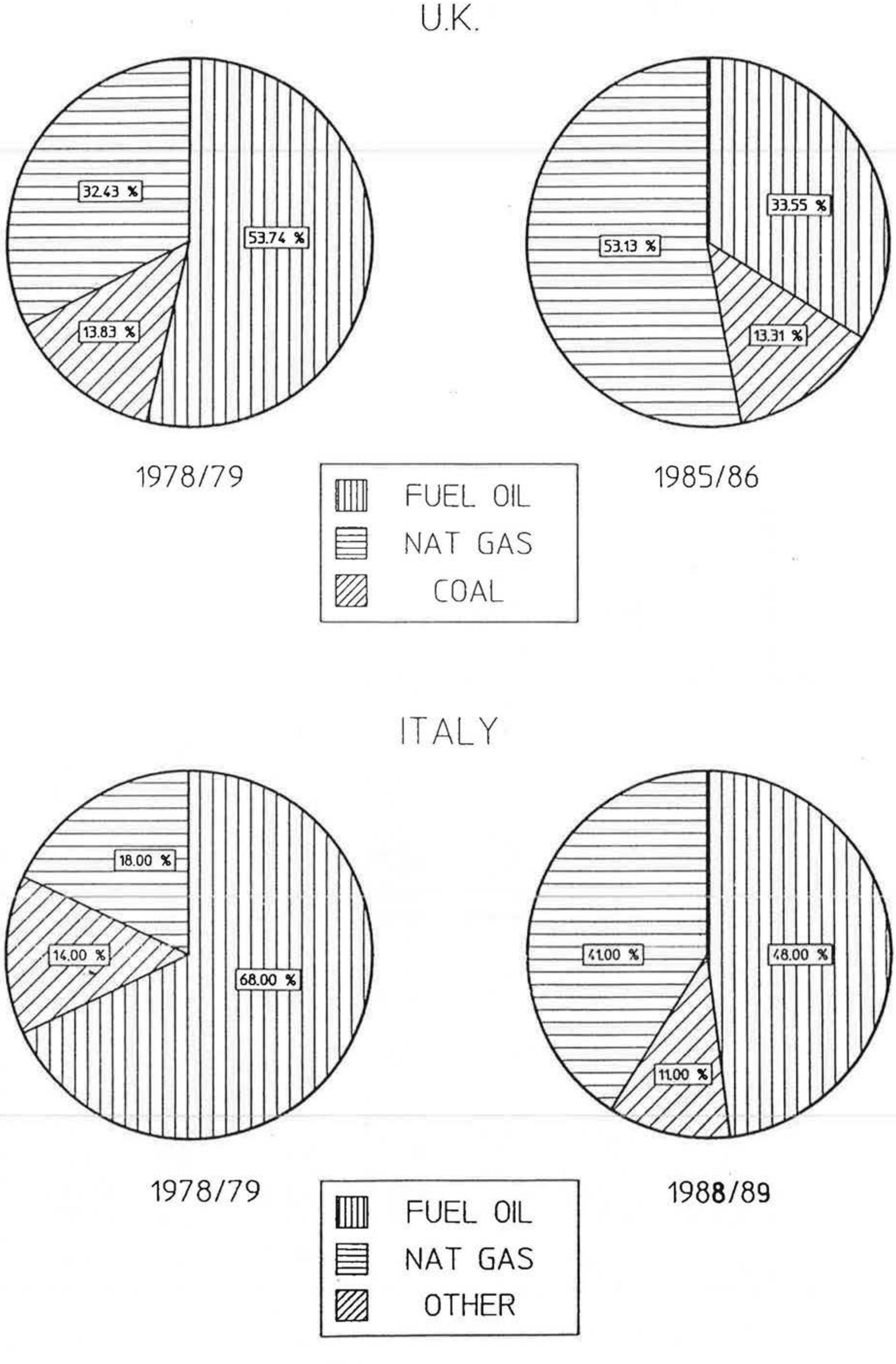

Fig. 10 - Type of Fuel employed in U.K. and ITALY

IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

COUNTRY :

SCHOOL:

TITLE /MEASURE:

DESCRIPTION OF INSTALLATION:

SAVINGS:

FURTHER INFORMATION FROM:

Fig. 11

APPENDIX 1

CASE STUDIES

"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.

N°		TITLE	1	2	3	4	5	6	7	8	9	SAVINGS
1	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Vandyke Upper School Point of Use Hot Water Facilities						X				Payback: 2 years
2	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Lady bay Infants Addition of an Insulated Suspended Ceiling to a Victoria School		X								- 15-25% reduction in energy - reduced fabric maintenance costs - improved environmental conditions including lighting and acoustics
3	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Alderman Pounder Infants, Nottinghamshire External Insulation to a Flat Roof		X								- 15-25% reduction in energy
4	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Bradworthy Primary School, Devon Use of Heat Pumps in a Ruad School							X			-21% energy cost saving, compared with oil at 1984 prices
5	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Haywood Comprehensive, Gloucestershire Swimming Pool. Automatic Ventilation Controls			X							- 22% enegy reduction -2 years payback
6	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Orchard House Primary, Cheshire Overoofing a Flat Roof with Insulation and Metal Decking		X								-35% reduction in energy consumption
7	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Wigton Schools Swimming Pool, Cumbria New Boiler and Flat Plate Heat Recovery, Permit Additional Mechanical Vnetilation without Additional Energy Consumption				X						-mechanical ventilation added without increased heat loss
8	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Queen Edith's Junior & Infants, Cambridgeshire Replacement Boiler, heat emitters and Provision of Energy Controls			X	X						-40% energy reduction
9	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Beacon Heath First Schools, Devon Automatic Lighting Control									X	-70% reducton in lighting usage

10	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Upcroft Junior, Berkshire Removal of Electric Water Heating, Boiler Rearrangement and Provision of on Energy Management System			X	X						- 30% energy reduction
11	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Rosslyn Infant School, Nottinghashire Optimiser Cntrol of Coal Fired Heating System			X							- Up to 40% saving in energy consumption - paybach: 2-3 years
12	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Cornforth County High, Lancashire Swimming Pool, Ventilation Control, Lightting Refurbishment and Cavity Insulation	X		X						X	- 25% energy reduction - improved lighating levels
13	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Litcham County priamry, Norfolk Replacement External Walls and Glazing	X									- 25% reduction in energy consumption
14	**COUNTRY:** **SCHOOL:** **MEASURE:**	England The Gilberd, Colchester Energy Management System in Multi Plant Room Installation			X							- Energy savings: 24,054 therms - Payback: 2 years
15	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Sunmers County Primary, Harlow Energy Management System in Shared-Use Environment			X							- Savings: 3.300 £/years - Payback: 2,25 years
16	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Tendring High School, Thorpe le Soken Energy Management System			X							- 35% reduction in energy consumption - Payback: 4,2 years
17	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Thorpe Bay County High, Southend on SEA Complete remdeling	X					X				-30% reduction in energy consumption per mq floor are -30% redcution in energy consumption per pupil
18	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Notley High School, Braintree Glanzing Insulation	X									- savings: 3.454 £/year -Payback: 4.3 years
19	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Nazeing County primary Thermosyphoning air panels incorporated into a refurbishment programme								X		- payback based on actual installed costs: 23.6 years

20	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Burnt Mill Comprehensive, Harlow Improved Heating Control & Swimming Pool										
21	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Cecil Jones COunty High, Southend-on-Sea Low Cost Measures	X		X							- savings: 3,805 £/year - Payback: 2,75 years
22	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School "E. Filiberto" Vimercate (MILANO) "Heating plant improvement"			X							- 9,5% reduction in energy consumption
23	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School "E. Filiberto" Vimercate (MILANO) "Building Insulation Improvement"	X	X								- 16,7% redcution in energy consumption
24	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School "A. MANZONI" Vimercate (MILANO) "Heating Plant Improvement"			X	X	X					- 17,9% reduction in energy consumption
25	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School "A. MANZONI" Vimercate (MILANO) "Building Insulation Improvement"		X								- 13,7% redcution in energy consumption
26	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Nusery School "Nord-Est" Vimercate (MILANO) "Heating Insulation Improvement"			X	X						- 16,3% reduction in energy consumption
27	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Nusery School "Nord-Est" Vimercate (MILANO) "Building Insulation Improvement"	X									- 4,8% reduction in energy consumption
28	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School, Sumirago Installation of a High Efficiency Boiler Installation of a BEMS			X	X						- 19% reduction in energy consumption - improved comfort conditions
29	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School, Sumirago Increased Envelope Insulation	X	X								- 14% reduction in energy consumption - improved comfort conditions
30	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Nuserry School, Piancogno Solar Collector for DHW Production, Installation of a BEMS			X					X		- 24% reduction in energy consumption

31	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Nursery School, Piancogno Basement Insulation		X								- 5% reduction in energy consumption
32	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School, Casnigo Reduction of Boiler Capacity and Installation of Two Gas Fired Modules				X						- 20% reduction in energy consumption
33	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Secondary School, Casnigo Reduction of Window Area, Double Glazing to all WIndows, Increased Envelope Insulation	X	X								- 22% reduciton in energy consumption
34	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School, Lanzada Solar Air Collectors Connected to a Ventilation System								X		- 25-28% reduction in energy consumption - improved comfort conditions
35	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School, Lanzada Increased Envelope Insulation, Double Glazing on North Side	X	X								- 15-16% reduction in energy consumption - improved comfort conditions
36	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School, Montorfano Ventilation System with Solar Air Collectors								X		- 25% reduction in energy consumption - Improved comfort conditions
37	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Elementary School, Montorfano Increased Envelope Insulation, Double Glazing of the Classroom Windows	X	X								- 5-6% reduction in energy consumption
38	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Technical School "Sommeiller" + High School "G. Ferraris", Torino Flue Damper Control, Boilers, Sequency, Thermostatic Valves on Radiators			X							- 2./% reduction in energy consumption - Payback: 6,7 years
39	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Technical School Rivoli (Torino) Optimisation system, Boilers, Sequency, Radiator Thermostat Valves			X							- 3% reduction in energy consumption - Payback: 6,5 years

40	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Technical School "G. Grassi", Torino Optimisation system, Boilers Sequency, Radiator, Thermostat Valves, Flue Damper Control			X							- 2.6% reduction in energy consumption - Payback: 10 years
41	**COUNTRY:** **SCHOOL:** **MEASURE:**	Italy Technical School "Barocchio" Grugliasco (Torino) Optimisation system, Boilers, Sequency, Radiator Thermostat Valves			X							- 3% reduction in energy consumption - Payback: 10 years
42	**COUNTRY:** **SCHOOL:** **MEASURE:**	England The Priory School Hitchin, Hertfordshire Maind signalling for zone control			X							- Payback: 6 months
43	**COUNTRY:** **SCHOOL:** **MEASURE:**	England Frankland School Hoddesdon, Hertfordshire Replacement electronic room thermostats			X							- Payback: 6 months
44	**COUNTRY:** **SCHOOL:** **MEASURE:**	Engalnd Ashling School Berkhamsted, Hertfordshire 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.

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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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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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 (5)

ENERGY EFFICIENT CASE STUDIES

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.

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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:

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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.

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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:

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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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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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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.

FURTHER INFORMATION FROM:

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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.

FURTHER INFORMATION FROM:

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IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

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:

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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 29.08.88.

SAVINGS:

Fuel cost for the first year from 01.11.88 to 01.11.89 are 0,683 therms @ 39.8 = £ 3854 with a year's saving of £ 3,300

Payback will be in 2.25 years on the basis of te 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 on 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. Enhaced 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 circuts 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, totether with the addition of thermostatic radiator valves.

SAVINGS:

a 30% reduction in energy consumption cost per m^2 floor area

a 34% reduction in energy consumption cost per pupil

FURTHER INFORMATION FROM:

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IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

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 50 mm 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 memebers. 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 advantage:

- 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	£ 3,354
Payback period 4.3 years	

FURTHER INFORMATION FROM:

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IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

COUNTRY: ENGLAND

SCHOOL: NAZEING COUNTY PRIMARY

TITLE /MEASURE: THERMOSYPHONING AIR PANELS INCORPORATED INTO A REFURBISHMENT PROGRAMME

DESCRIPTION OF INSTALLATION:

101 m^2 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 perfomance from each collector was estimated to be 500 MJ/m^2/annum which represents 14,000 kwh per annum for the 101 m^2 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 sytem are 23.6 and 14.7 years respectively.

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IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

COUNTRY: ENGLAND

SCHOOL: BURNT MILL COMPREHENSIVE, HARLOW

TITLE /MEASURE: IMPROVED HEATING CONTROLS & SWIMMING POOL

DESCRIPTION OF INSTALLATION:

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

Actions

School
zoning
improved controls
extensive glazing insulation

Swimming pool
pool covers
high efficiency lighting
shower timers

SAVINGS:

Not yet know

FURTHER INFORMATION FROM:

D.M. Curtis
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IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

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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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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20151 MILANO

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%

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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%

FURTHER INFORMATION FROM: Dr. Ing. Mario DE RENZIO
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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: Dr. Ing. Mario DE RENZIO
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(26)

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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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: Ing. Sergio ZABOT
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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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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.

FURTHER INFORMATION FROM:

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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:

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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

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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)

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)

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COUNTRY: ENGLAND

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
ENGLAND

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
E N G L A N D

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
E N G L A N D

APPENDIX 2

SEMINARS

"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.

Paper presented in the Seminar

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 "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. Covari**

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.

"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** Energy Manager Essex County England Council Chelmsford, Essex.
Passive solar design: the Local Authority experience	**D. Poole** Welsh School of Architecture, Cardiff
Energy performance assessment of Lool junior and infant school	**D.K. Alexander** **N.D. Vaughan,** **H.G. Jenkins,** **P.E. O'Sullivan**
Passive solar buildings and bioclimatic architecture in Italy	**V. Corrado** Energy Department Politecnico of Torino
Two retrofitted buildings with passive and hybrid systems in Italy	**S. Zabot** Energy Issue Department Regione Lombardia Via F. Filzi, 22 MILANO
DES project on guidelines on Passive Solar Design and general U.K. overview	**Prof. B. Norton** University of Ulster (formerly at Cranfield 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.

"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.

Paper presented to the seminar

Activity of ENEA. Rationaluse of Energy	**P. Pittimada** ENEA - Rome
Activity of F.I.R.E.	**G. Ferrari** FIRE - Rome
Construction of school Buildings in Italy.	**M. Guarineri Cannizzaro** Ministry of Education Rome
Functions and actions of Ministry of Industry	**A. Pela** Ministry of Industry Rome
Activity of I.E.A. in the School sector: Annex XV "Energy Efficiency in School"	**R. Lazzerini** Studio Lazzerini Torino
Energy conservation in existing education establishments. U.K. overview	**R. Bowen** Chief Heating Engineer Hertfordshire County Council. U.K.
Schools in Rome Province: analysis from an energy point of view	**A. Cellie** Education Dpt Province of Rome Rome
Possible application of solar systems to school buildings	**G. Sorinello** Rome City Council Rome
Retrofitting actions performed in Schools in Lombardia Region	**L. Burzilleri** **S. Zabot** Energy Dpt Lombardia Region Milan
Energy efficiency in Schools in Regione Lazio	**C. Colizza** Energy Dpt Regione Lazio Rome
A methodology for energy audit in schools developped by ENEA	**D. Guarino** ENEA Rome
Use of models of dinamic simulation for energy evaluations	**M. Arduindi** **T. G: Biserna** M. Citterio Milan
Energy diagnosis	**L. Angelone** ENEA-FARE Rome
Energy monitoring in Schools	**M. Romanazzo** ENEA-FARE Rome

The experiences & activities of Essex County Council	**D.M. Curtis** Essex County Council U.K.
Retrofits performed in Schools in Vimercate	**M. De Renzio** Sinerga Milano
Managing energy for School buildings	**W. Bohnenschäfer** Gertec Consult Engin. Essen (R.F.T.)
Energy efficiency of Schools in Livorno	**C. Fantozzi** **C. Rini** Energy Dpt Livorno Council Livorno
Retrofit actions in School building in Province of Trento	**G. Carlino et al.** Energy Dpt Province of Trento 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.

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.

Papers presented to the seminar

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 future decision makers in society at large.	**Mukund Patel** Department of Education & Science
Good practice and guidance from the Centre in a Public Sector organisation. Technical measures: financial justification	**David Curtis** Energy Manager Essex County Council
Good practice the Self Help Way. Experience from a Private School. Housekeeping; Monitoring; Motivating; Managing.	**Mike Flett** Bursar The Norwich School
Energy Strategy for future Managers in LEA Schools. Options for Partnership. Image and reality. Planning for good performance.	**Alan Tyler** Deputy County Architect Hertfordshire
Energy in the School Curriculum	**Les Hewitt** 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 therofore 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.

Energy economy

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.

"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.

Paper presented in the Seminar

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

- management and maintenenance failures
- quality of materials
- components
- design or construction mistakes
- other

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.

Heating system

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.

"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** Norkfolk County Council
Working with tariffs	**Alex Spivey** Eastern Electricity
Good management of lighting and computers	**Mike Flett** Bursar Norwich School
Lighting and equipment controls	**Robin Aldworth** Thorn Lighting
Domestic hot water	**Trevor Rowe,** 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.

Hot water

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.