I.E.A. INTERNATIONAL ENERGY AGENCY

ENERGY CONSERVATION IN BUILDINGS AND COMMUNITY SYSTEMS

ANNEX XV - "ENERGY EFFICIENCY IN SCHOOLS"

FINAL REPORT

PART ONE: TEXT

Torino, July 1991

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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 [m^2/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/m^2 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 · 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
- POPULATION		57,000,000
- NUMBER OF PUPILS		8,000,000

- SURFACE	km^2	301,000
- POPULATION		56,000,000
- NUMBER OF PUPILS		8,650,000

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

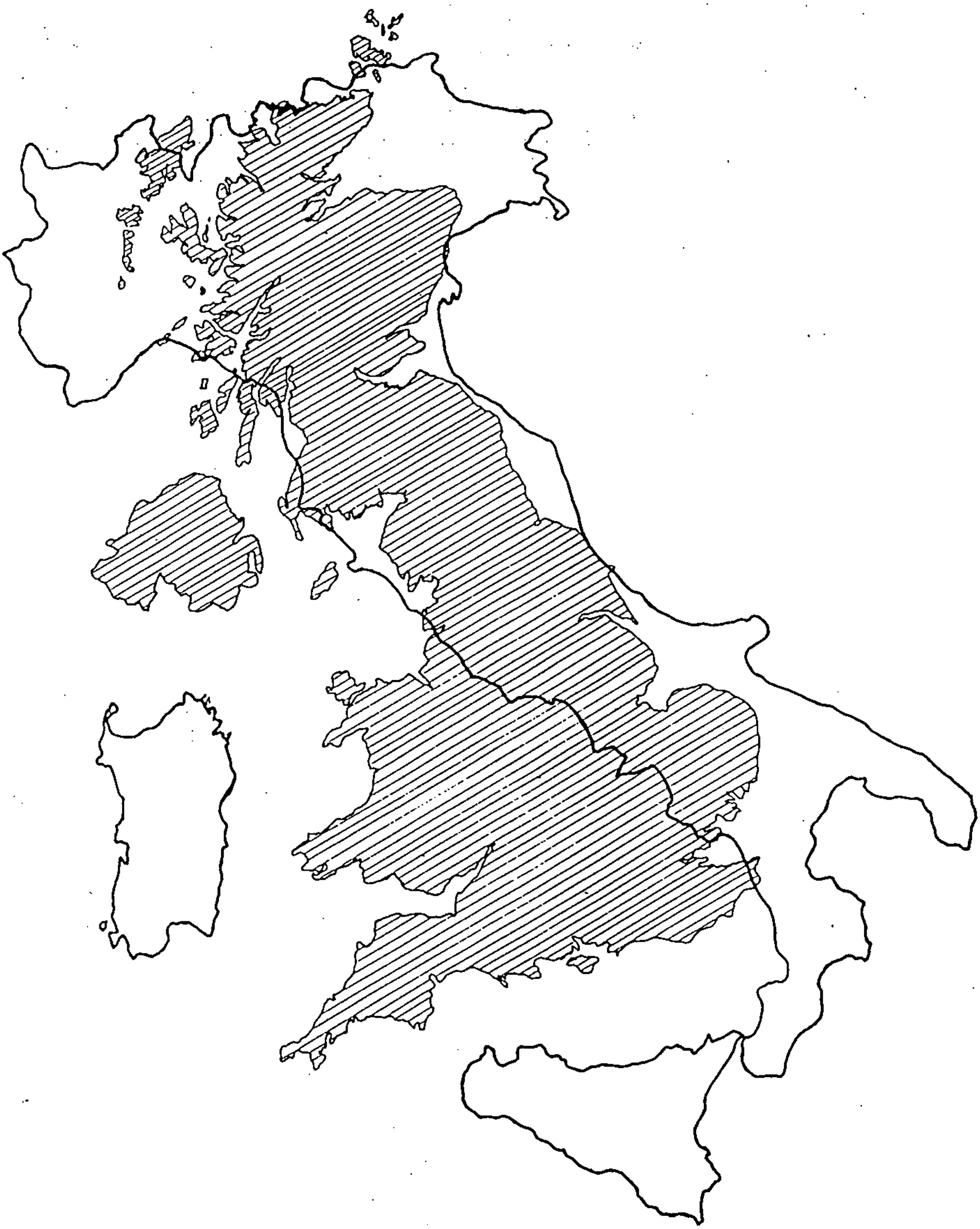
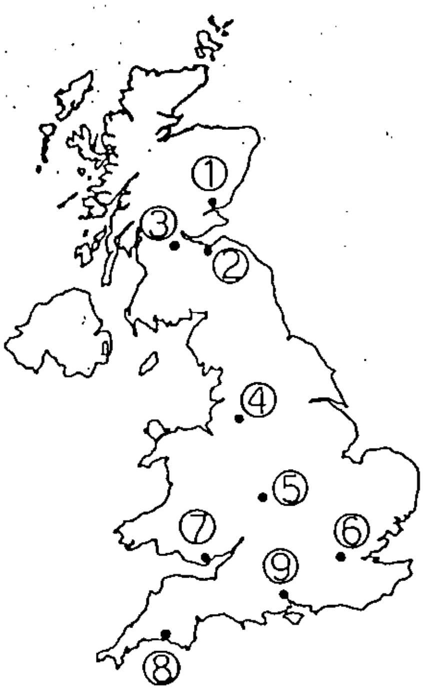


Fig. 2 - Comparison of maps of U.K. and ITALY
- U.K.
- ITALY



		°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

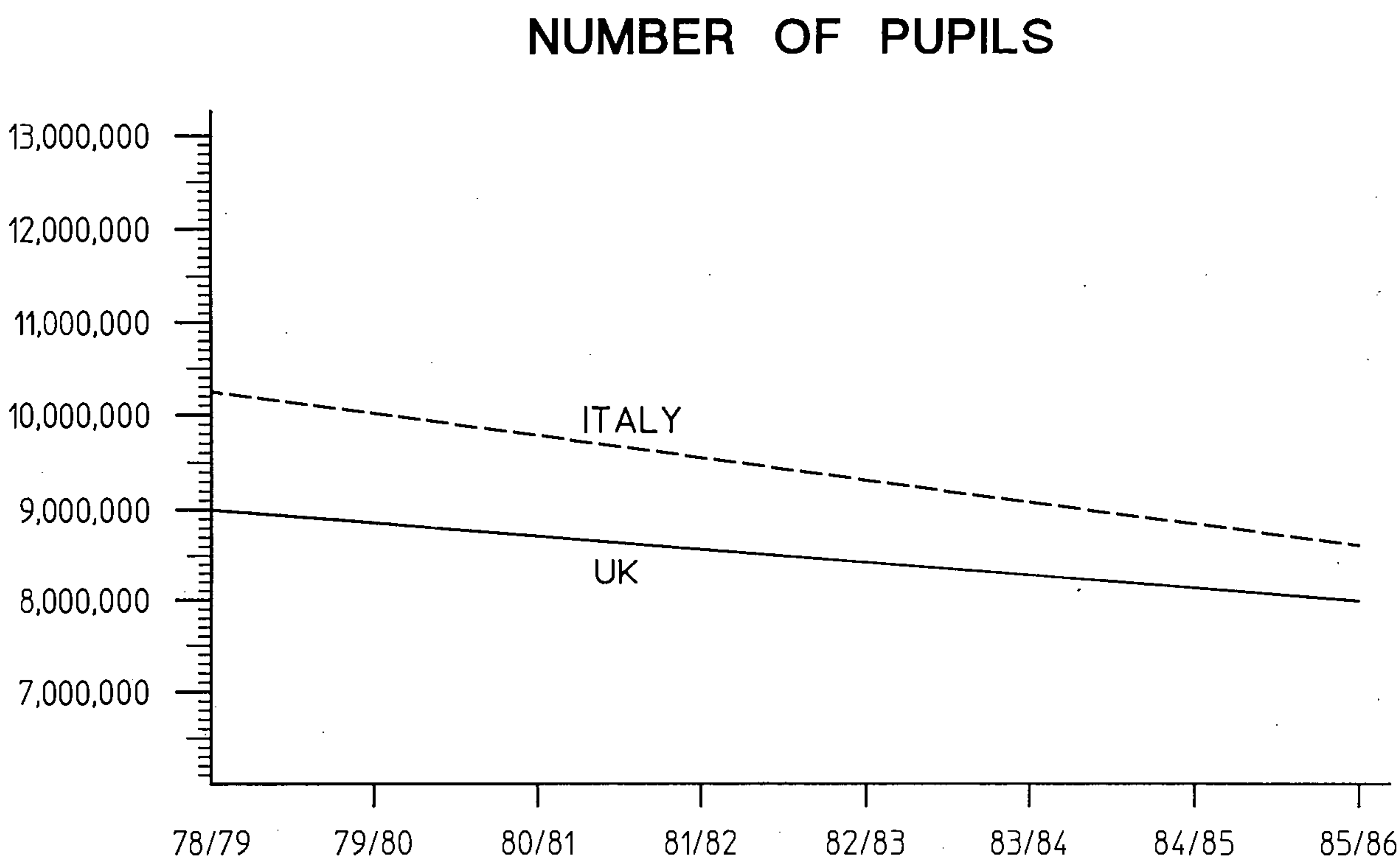


Fig. 4 - Variation of the number of Pupils in U.K. and ITALY

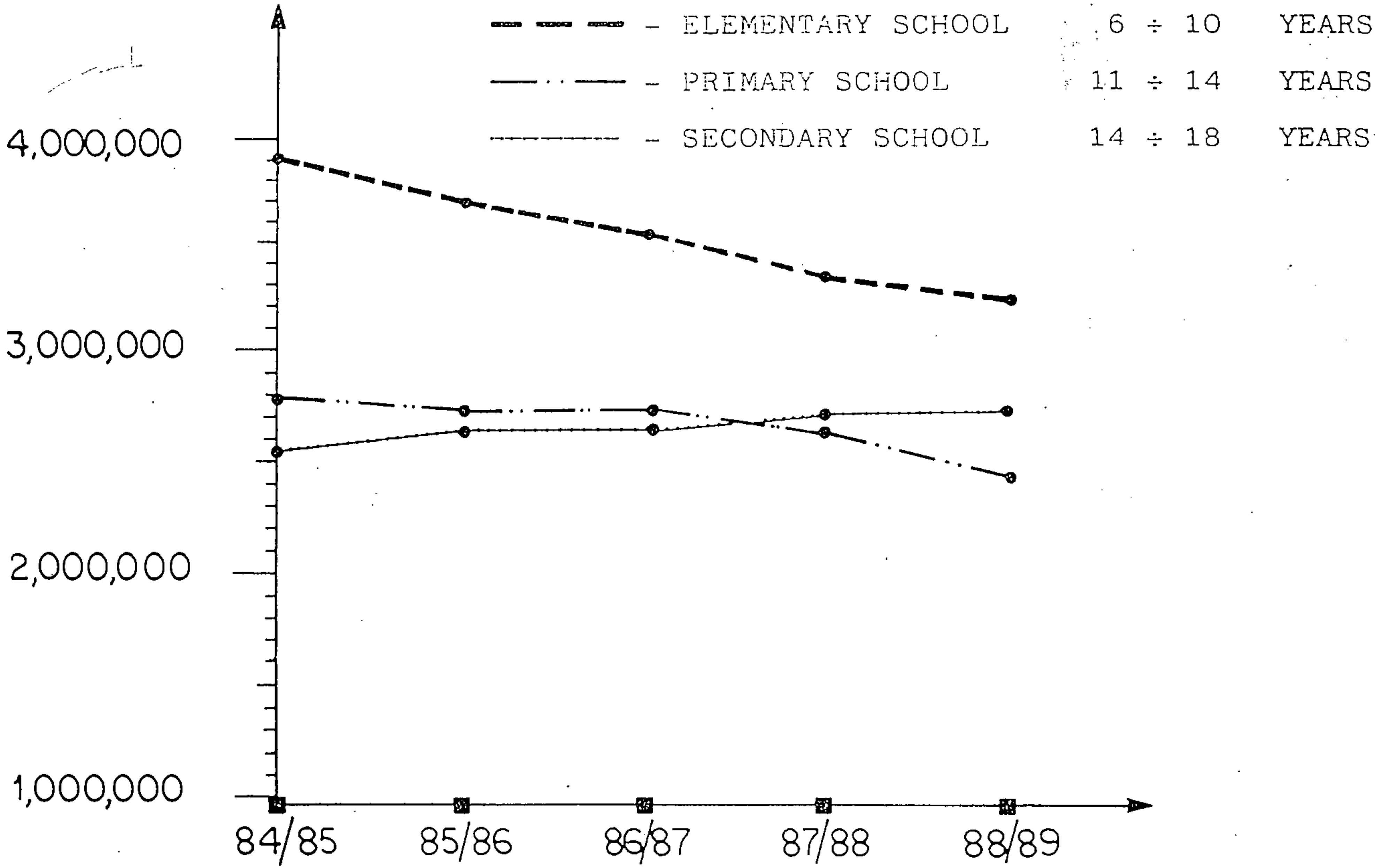


Fig. 5 - Variation of the number of Pupils in ITALY considering various types of Schools

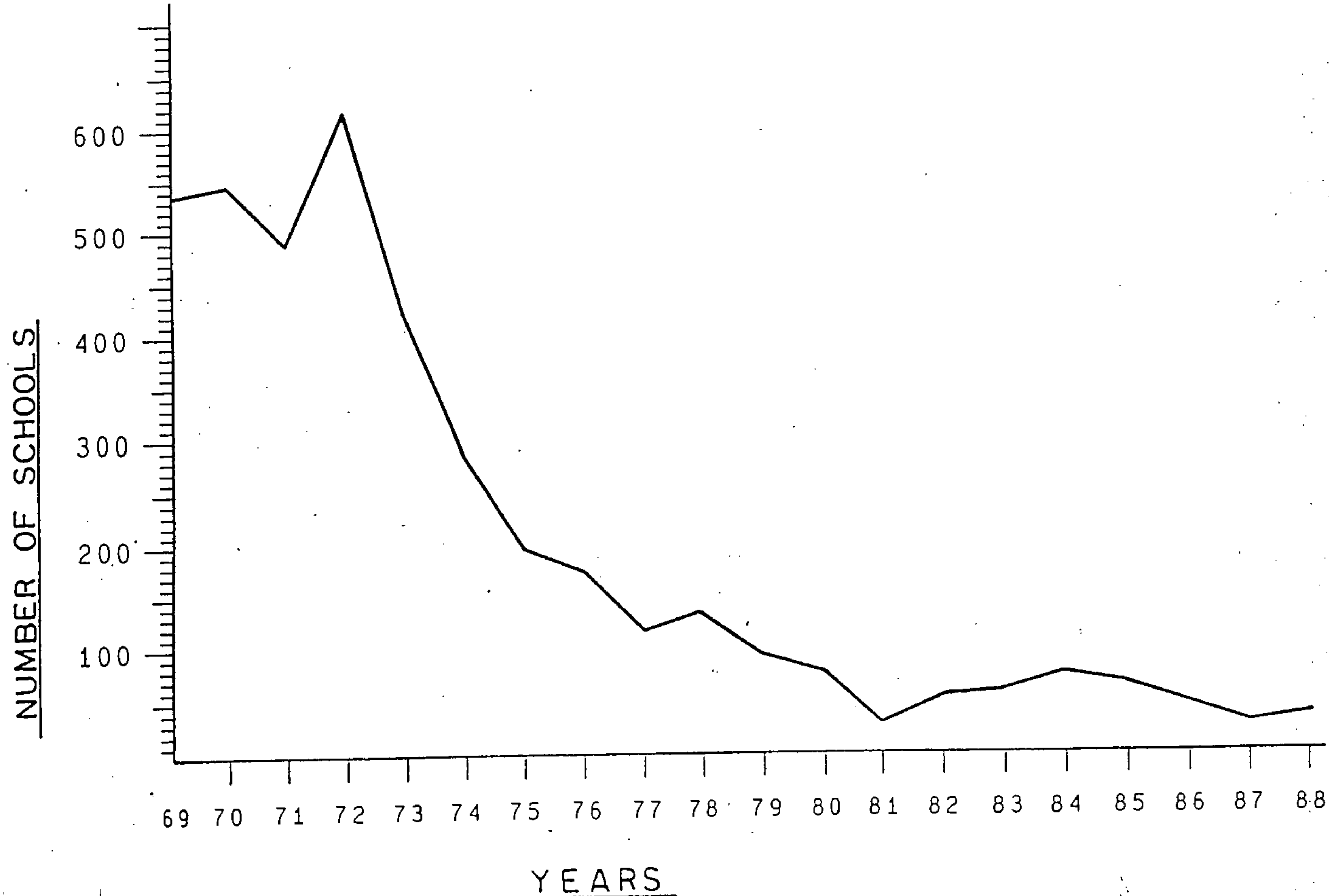


Fig. 6 - Number of new schools built in U.K.

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

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

Thermal energy consumption

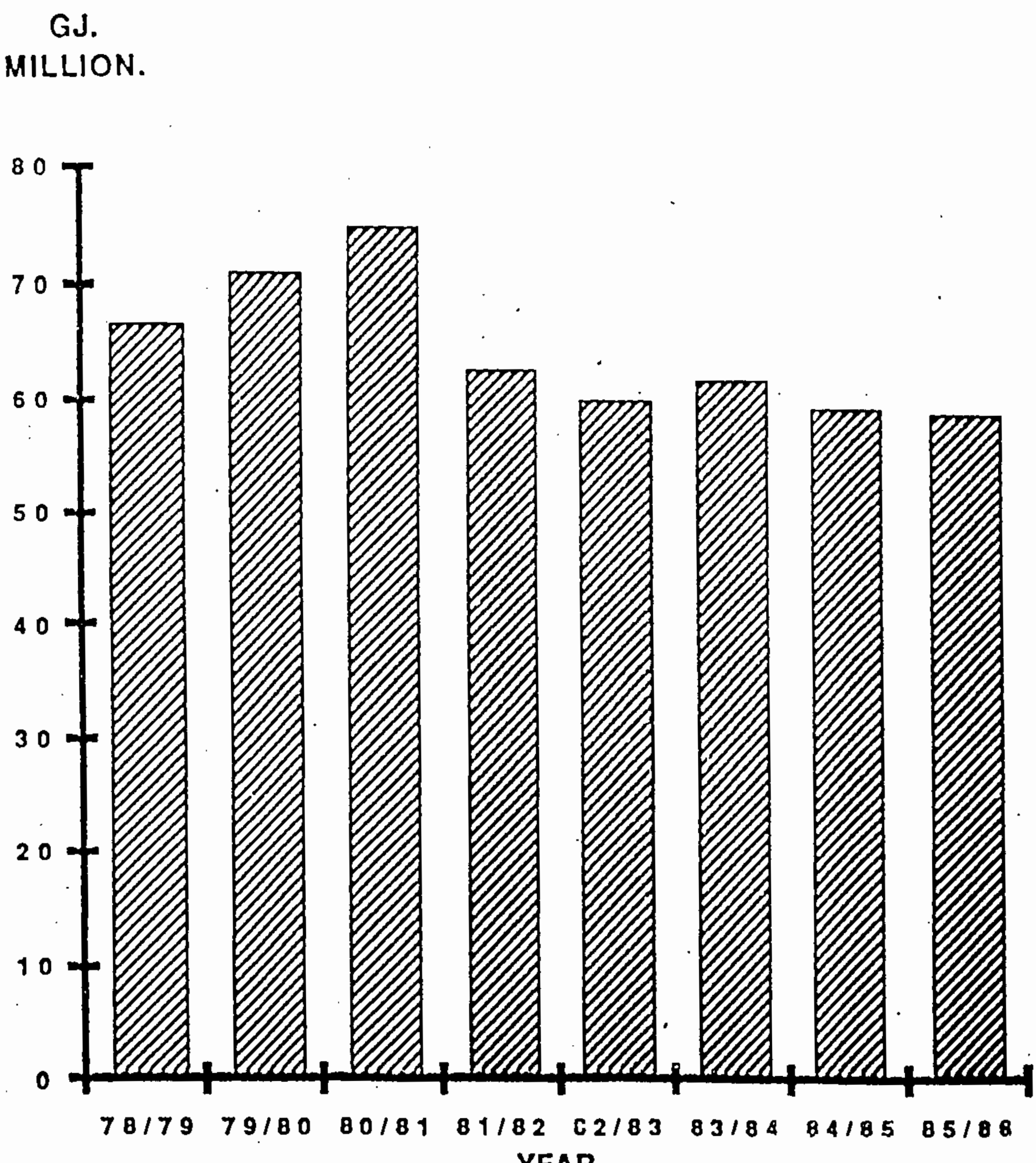


Fig. 9- Thermal Energy Consumption in Schools in U.K.

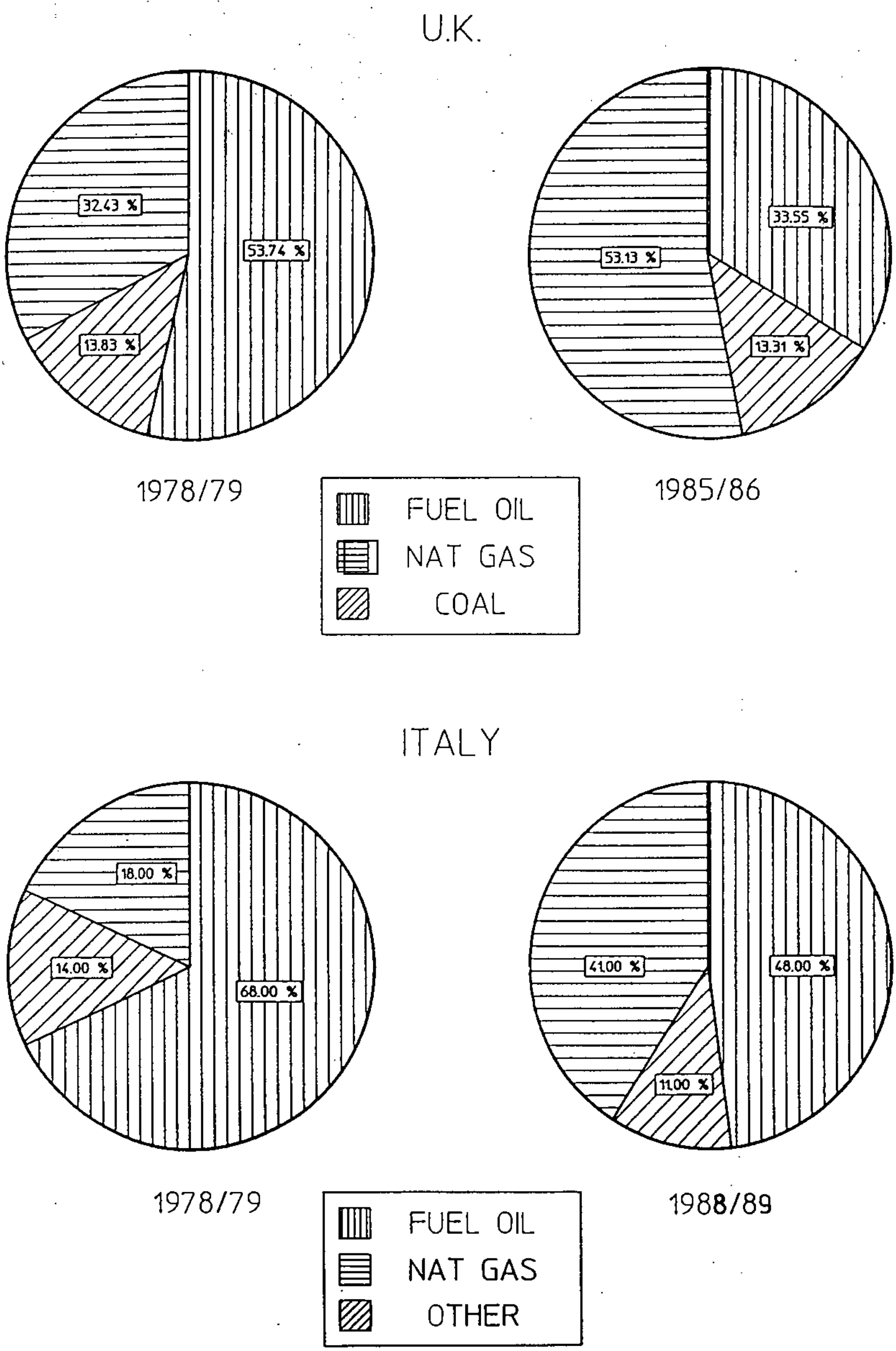


Fig. 10 - Type of Fuel employed in U.K. and ITALY

IEA ANNEX XV - ENERGY EFFICIENCY IN SCHOOLS

ENERGY EFFICIENT CASE STUDIES

COUNTRY:

SCHOOL:

TITLE /MEASURE:

DESCRIPTION OF INSTALLATION:

SAVINGS:

FURTHER INFORMATION FROM:

Fig. 11