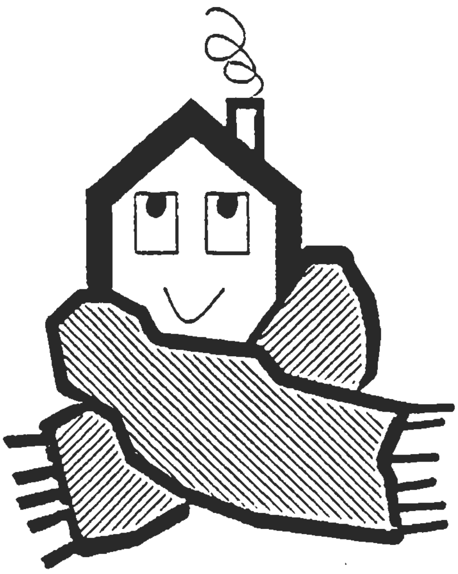
INTERNATIONAL ENERGY AGENCY
energy conservation
in buildings and community
systems programme

Working Group on
energy efficiency
in educational buildings

FINAL REPORT



JUNE 1996

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1. FOREWORD

1.1. International Energy Agency

The International Energy Agency (*IEA*) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD). Its purpose is to implement an international energy programme. It carries out a comprehensive programme of energy co-operation among 23 of the OECD's 24 member countries, and allows for the participation of non-member countries.

The challenges the IEA member countries face in the energy sector have evolved over the past two decades. Energy security remains a primary goal, but in recent years there has been increasing awareness of the significance, for energy policy and energy security, of two further factors: concern over the environmental impact of energy-related activities and the growing globalisation of energy issues, as countries' economies and energy markets become increasingly interdependent, but nevertheless different in terms of energy sources, price etc.

Member countries of the IEA recognise that they develop their energy policies within a context of increasing global interdependence, and seek to promote co-operative relationships among all energy market participants, which helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets world-wide.

In the frame of the Energy Programme, the I.E.A. sponsors research and development in a number of areas related to energy, giving priority to the following options and initiatives:

- enhancing multilateral co-operation in energy technology;
- removing barriers to market deployment of new technology;
- establishing a technology information exchange.

The environmental effects of the use of fossil fuels are becoming more and more obvious, and concern is increasing rapidly. In calculations of the cost-effectiveness of energy savings such factors as acid rain, the green-house effect and the management of nuclear waste have not yet been included.

At such a time that this will be possible, the previous strong connection between energy saving measures and cost-effectiveness will be lessened, and instead energy-saving will be associated with protection of the environment and quality of life.

The awareness of the close links between energy use and the pollution of air, ground and water have increased considerably. It is now recognised that in order to achieve the objectives of a combined energy and environment policy, the type and extent of energy conservation in the built environment are decisive. The development and introduction of new low-energy and minimum-pollution heating technologies are now topical.

Target values for energy savings in the building sector have been set in many IEA countries to complete their CO_2-reduction programmes. Typical measures to promote energy efficiency are energy standards, new building codes, energy trusts, taxation, dissemination of information, demonstration and Demand Side Management projects. Technical solutions are based on minimising thermal losses (high performance windows, envelopes, heat recovery); on efficient use of delivered energy (advanced technical systems); and on the optimised active and passive usage of solar energy. Furthermore, the next decades are in many countries seen as a period during which fossil fuels will be replaced by renewable energies in heating and cooling of buildings.

In the building sector energy saving objectives are from 15 to 30% in terms of specific energy consumption, and in individual cases the target is to introduce low-energy building concepts with consumption of less than one quarter of the standard in new buildings, and less than a half in existing buildings, respectively.

Considering the large picture, schools represent only a minor fraction, but considerable amounts of energy are generally required for the operation of all systems and services within a school, and large amounts of energy are reported to be wasted; the necessity of a more rational management of the energy involved has been generally recognised.

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

1.2. The Working Group on "Energy Efficiency in Educational Buildings"

This **Final Report** summarises the complete work performed in three years activity by representatives of the five Countries participating to the I.E.A. **Working Group "Energy Efficiency in Educational Buildings"**.

This project represents the continuation of a previous I.E.A. programme **"Annex XV - Energy Efficiency in Schools"**, in the frame of a bilateral agreement between U.K. and Italy, started in 1988, with a 2½ year activity.

That project was inspired by an OECD seminar held in Vienna and has resulted in a useful series of seminars held in both Italy and the UK. A statistical comparison covering all aspects of internal and external environment in school buildings, as well as energy use, has assisted both countries in identifying on a national scale, where energy saving efforts could best be directed. Many of the experiences of one country were able to be directly transferred to the operations of the other.

As this bilateral agreement concluded its task at the end of 1990, following the successes of this project, the project team (consisting mostly of those responsible in the two countries for energy efficiency in school buildings) considered that much of this information would be valuable to other countries for comparative purposes, and also that the seminar and research activity should continue.

A proposal was therefore presented to the Executive Committee Meeting on 29-30 May 1991, to continue this activity and to extend it to cover all educational buildings, inviting other countries to join.

The Executive Committee agreed to the continuation as outlined in attachment 8 of the summary of the Proceedings of the same ExCo Meeting.

A trial would be conducted of all other EEC countries to see if there was interest from other areas: an I.E.A. Planning Meeting was proposed on 11 October 1991 in Cambridge, open to delegates of all those countries who might be interested in participation.

If, after this Planning Meeting, there was sufficient interest for a new Annex in addition to the proposed bilateral workplan, this would be put to the Committee at its next meeting.

Ten persons attended the planning Meeting, representing the following countries:

- Austria
- Greece
- Italy
- Spain
- U.K.

Conclusions of this Meeting were the following:

- representatives of the five countries attending the meeting considered an extension to the project was appropriate and were interested in being involved;
- proposals were formulated to extend the future activity to all educational buildings: colleges, swimming pools, sport buildings, etc.;
- consequently a new name for the task was proposed: "Energy Efficiency in Educational Buildings";
- a tentative workplan was prepared to submit to the next Executive Committee Meeting, 27-28 November 1991;
- the proposed duration of this project was 3 years, starting January 1st 1992, ending December 31, 1994.

As reported in the Summary of the proceedings of the meeting held in LEUVEN, 27-28 November 1991, point 5.11, the Executive Committee agreed to sponsor this project, named **Working Group on Energy Efficiency in Educational Buildings**.

2. OBJECTIVES OF THE WORKING GROUP

According to conclusions of the Preparatory Meeting held in Cambridge on October 11, 1991, and experience arising from the previous work undertaken by Annex XV, the main objectives of this project are the following:

- identify the situation existing in all participating countries, related to problems associated with schools, collecting all data concerning energy consumption in systems normally existing in schools;
- consider all aspects of the internal and external environment in school buildings, as well as energy use, in order to identify where energy saving efforts could best be directed;
- make comparisons among situations existing in different countries participating in this project in all fields related to activities of the school and the use of energy, in order to verify the possibility and the opportunity to adopt the positive results obtained in one country also in other countries;
- evaluate the energy saving potential of different measures which can be taken in school buildings and systems;
- prepare **Guidelines** with recommendations on the use of new and existing energy management technologies, and provision of maintenance advice to assist in efficiently operating systems and equipment.

3. ACTIVITY OF THE WORKING GROUP

To fulfil the objectives of this Working Group, each participating Country appointed a team of experts: the names and affiliation of the experts who have taken part in this work are listed below.

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

The work performed by the Working Group has been the following:

- analysis of regulations and standards concerning school design and operation existing in all participating countries;
- collection of statistical data and other elements related to schools, in all countries;
- collection and analysis of case studies of retrofitting actions in Schools performed in participating countries;
- organisation of Seminars on special topics concerning schools;
- regular meetings of the Working Group for analysis of results, discussion of reports, exchange of information.

3.1. Structure of the Final Report

This Report is divided into seven parts, as follows:

- **Part 1 - General.** Collection and presentation of statistical data and elements concerning school life in the five participating countries: in this section are reported data and information not only directly related to energy consumption in schools but also other data concerning general aspects of the considered countries, such as: population, geography, climate, industrial development, environment control, structure and organisation of the school, number and age of pupils, curricula, standards and regulations, etc.: these elements influence the life itself of the school, and eventually affect the behaviour of the occupants with the consequent use and consumption of energy.
  Main data and information have been taken from International statistic yearbooks, and national yearbooks in all countries, as far as possible.

- **Part 2 - Seminars.** The organisation 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 updating of results.
  Six seminars have been organised in turn by the five participating Countries, reported later in more detail.

- **Part 3 - Energy and Environment.** The emergence of the threat to the environment from greenhouse gases has reinforced the financial argument to reduce energy consumption.
  The major way that authorities can contribute to a reduction in greenhouse gases and a cleaner environment is to follow a policy of improving the energy performance of their building stock.
  Schools account for a large part of the national energy bill. They therefore deserve close examination.

- **Part 4 - Energy and Curricula.** 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 and Education.
  Energy issues can be integrated into the curriculum and project work. Pupils can use their own school building as a real life experiment by monitoring its energy consumption and assessing the impact of energy efficiency measures.

Better control of energy use usually results in improved conditions for teachers and pupils alike.

- **Part 5 - Energy Efficient New Schools.** In recent years, many modern new schools have been constructed and are now in operation, in all of the five countries participating in the I.E.A. Working Group.
Details and main characteristics of some of the new schools, whose operation started after 1985, in the five countries, are reported.
They represent examples of what can be achieved by applying basic principles of energy conservation, comfort, respect for the environment, complete with the use of tried and tested energy efficient heating, lighting, room ventilation, insulation, etc.

- **Part 6 - Energy Conservation Measures.** The possibility to successfully perform the mentioned energy saving programme depends on the actual availability of men, time, means, and money.
The work performed so far by the Working Group, with results and data drawn from seminars, meetings, examination of documents and discussions, 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.
The energy conservation measures generally considered suitable for school buildings and systems are reported.

- **Part 7 - Guidelines for energy efficient management and maintenance in schools.** The purpose of this Guide is to help School Energy Managers to use energy efficiently in their schools. There are many ways of achieving this, ranging from improving the energy awareness of staff and pupils to investing in improvements to the heating system.
This Guide is designed to better understand the factors that influence the size of the school's energy bills. It describes the importance of regular monitoring of fuel consumption and outlines the first steps which can be taken to cut out the wasteful use of energy.

3.2. Working Group Members

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PART ONE - GENERAL INFORMATION

4. GENERAL STATISTICAL DATA

This section reports some general data concerning the actual situation existing in the five participating countries: surface area, population and climate conditions.

4.1. Surface area and population

Data concerning overall population have been taken from recent published statistics, and refer to 1991.

4.1.1. Austria

- Area 84,000 km^2
- Population 7,820,000

4.1.2. Greece

- Area 132,000 km^2
- Population 10,100,000

4.1.3. Italy

- Area 301,000 km^2
- Population 57,800,000

4.1.4. Spain

- Area 506,000 km^2
- Population 39,000,000

4.1.5. U.K.

- Area 244,000 km^2
- Population 57,500,000

4.2. Climate conditions

In order to compare the climate conditions existing in the different countries, the value of Degree Days in 1991 is reported, as well as the following data for several towns in each country:

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

4.2.1. Austria

	(a) [m]	(b) [°C]	(c) [°C]	(d) [°C]
Vienna	202	11.1	3.4	21.8
Innsbruck	577	10.3	3.8	20.2
Salzburg	430	10.1	3.1	19.7
Linz	297	9.7	1.4	19.8
Klagenfurt	447	8.6	-0.8	20.1
Sonnblick	3,106	-5.4	-9.9	3.3

4.2.2. Greece

	(a) [m]	(b) [°C]	(c) [°C]	(d) [°C]
Athens	107	18.4	7.3	27.3
Heraklion	48	18.7	10.5	25.7
Salonicco	61	15.6	3.3	25.8
Gianina	484	14.0	2.1	23.7
Larissa	73	15.4	2.1	26.4
Samo	49	18.7	10.0	27.1

4.2.3. 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
Genova	21	16.1	7.5	23.7
Bologna	60	13.6	1.2	24.0
Firenze	51	14.4	5.7	24.5
Roma	17	15.4	7.5	24.2
Napoli	30	16.9	9.0	24.9
Palermo	31	19.1	12.2	25.8
Cagliari	7	16.9	9.3	24.5

4.2.4. Spain

	(a) [m]	(b) [°C]	(c) [°C]	(d) [°C]
Madrid	667	15.1		
Barcelona	95	16.2		
Valencia	24	18.2		
Cadice	30	18.0		
Granada	774	15.4		
Palma de Mallorca	28	18.6		

4.2.5. United Kingdom

	(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

4.3. Degree days

The value of D.D. has been recorded in the participating countries. and is reported in Table 1. for the years from 1985 to 1991.

The D.D. figures were calculated using the base temperatures for each country which are quoted for each country in Section 7.1 and the figures for different countries are not therefore directly comparable.

Table 1 - Degree Days

COUNTRY	1985	1986	1987	1988	1989	1990	1991
AUSTRIA							
GREECE	1,690	1,672	1,516	1,578	1,429	1,225	1,569
ITALY	2,042	1,994	2,004	1,838	1,917	1,749	2,072
SPAIN	1,800	1,332	1,513	1,521	1,362	1,481	1,784
U.K.	2,852	2,846	2,784	2,551	2,470	2,367	2,708

5. NATIONAL ORGANISATION OF SCHOOLS

5.1. Structure of education

Education is structured in different ways in the five countries here considered, taking into account several aspects: age of pupils, number of week-days, length of education period, curricula, etc.

The situation existing in each country is here briefly reported.

5.1.1. Austria

The structure of the education system in AUSTRIA is summarised in Figure 1.

5.1.2. Greece

The structure of the education system in GREECE is summarised in Figure 2.

5.1.2.1. Pre-school education

Nursery education lasts for two years and is optional. The enrolment of infants is subject to their reaching the age of three and a half by 1 October of the first year of attendance.

Pre-school establishments are open five days a week and infants attend daily for three and a half hours.

Many nursery schools operate on the premises of primary schools.

5.1.2.2. Compulsory education

Compulsory schooling in Greece covers a period of nine years, six years in primary school, *Demotikon scholion,* and three in secondary.

Primary education

Greek children start compulsory education in a primary school in the year in which they reach the age of five and a half, not later than 1 October.

Primary schools can be either State schools or private institutions.

In State schools education is provided free of charge. Books are also provided free.

The amount of weekly teaching varies between 23 and 25 lessons; 23 in the first two years and 25 in the following. Greek primary schools operate a 5 day-week.

Curricula and syllabi for primary schools are issued by the Ministry of Education and apply to both State and private schools.

Figure 1 - Structure of Education in Austria

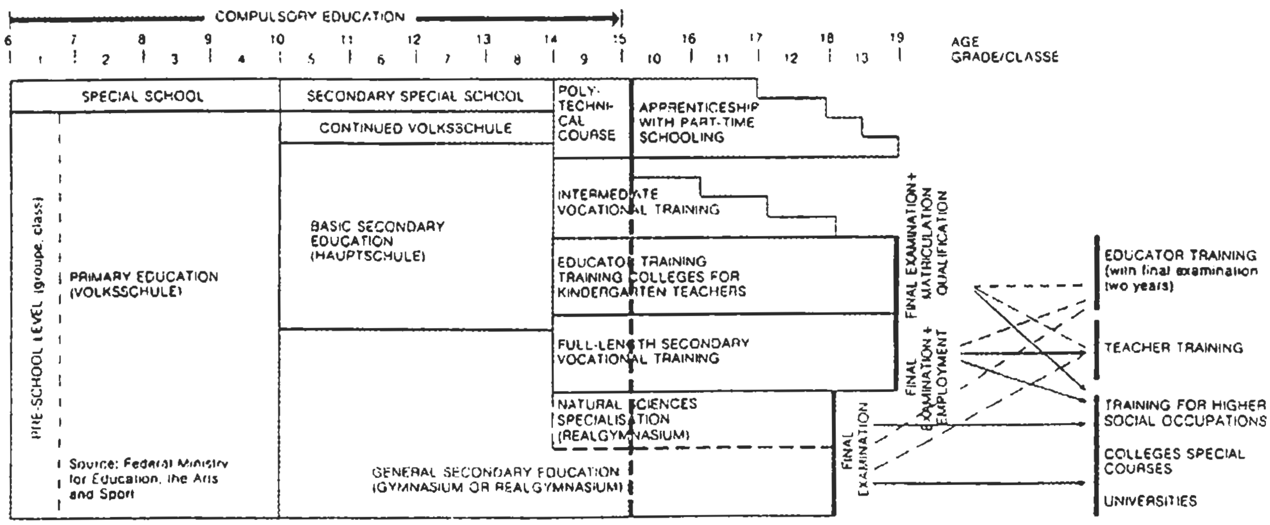
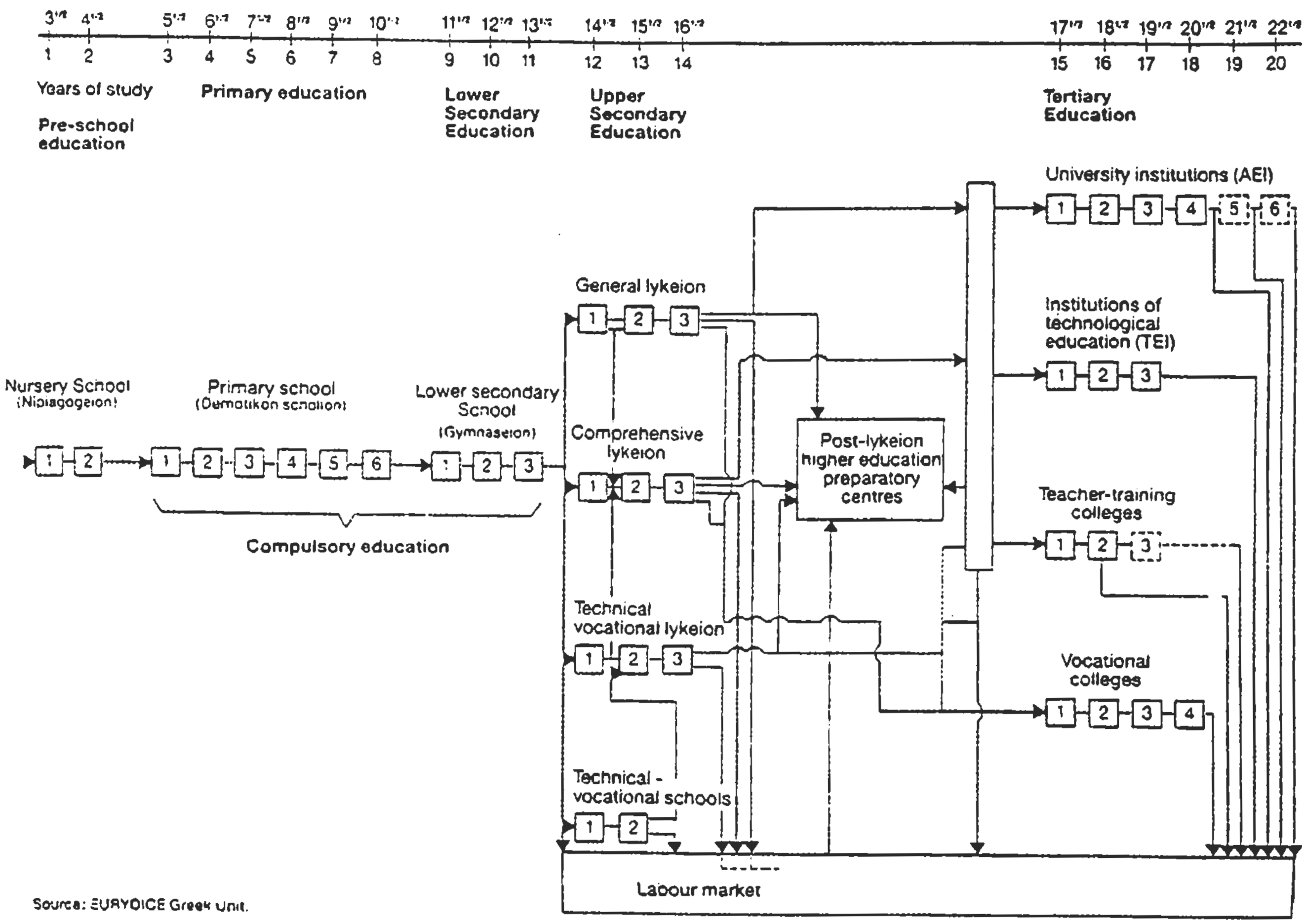


Figure 2 - Structure of Education in Greece



Source: EURYDICE Greek Unit.

Lower secondary education (Gymnasium)

The school of lower secondary education is called the *Gymnasium*. Attendance at this type of schools is compulsory.

The main objective of the Gymnasium is to contribute to the full development of pupils in accordance with their capacities and the demands of society.

Programmes last three years and there are 30 hours of tuition per week. The teaching year is divided into three periods of three months each.

Pupils graduating from the Gymnasium receive a leaving certificate called "Gymnasium Apolytirion".

Gymnasium graduates may be enrolled (without taking any examination) in all types of lyceum as well as in the technical-vocational schools.

5.1.2.3. Post compulsory education (upper secondary education)

The schools of upper secondary education are the *Lycea* and the *Technical-Vocational Schools.* When they have completed their studies at the Gymnasium, pupils can be registered in any school of upper secondary education.

Holders of the "Gymnasium" leaving certificate have automatic right of admission, without examination, to any of the four kinds of "lykeion": general, classical, technical vocational and comprehensive ("polikadiko").

Alternatively, they could attend one of the new type technical and vocational schools, or one of the privately run specialised vocational schools.

5.1.2.4. The Technical Vocational Schools

In addition to the Lycea upper secondary education includes the *TES* (*Technical Vocational Schools*) which aim to consolidate the general education of pupils and to prepare them for the world of work.

TES can be either State or private institutions. There are both daytime and evening TES.

Textbooks are offered by the State, free of charge. Programmes last for two years with the exception of evening TES where they last for three years.

Technical and Vocational Schools graduates can seek employment or be registered in the 1st year of all Lycea.

5.1.3. Italy

5.1.3.1. Pre-school education

Nursery education is operated by means of *Scuola Materna*, and is optional, with children reaching the age of three years by 1 September of the first year of attendance; activities last ten months from 1st September to June 30th.

5.1.3.2. Compulsory education

Compulsory schooling in Italy covers a period of eight years: five in elementary school, *Scuole Elementari*, and three in the first grade secondary education *Scuole Medie*.

Primary education

Italian children start compulsory education in Elementary School, *Scuole Elementari*, at the age of six: these are both State schools or private institutions.

Lessons last 215 working days, starting mid September up to mid June; this primary period lasts five years, from the age of six to eleven.

Curricula and syllabi for primary schools are issued by the Ministry of Education.

Lower secondary education

This last part of compulsory education lasts three years and is called *Scuola Media*.

Program last three years, per 215 working days, from mid September to mid June.

5.1.3.3. Post compulsory education

After completing their studies at any lower secondary school, pupils can be registered in the upper secondary schools, which are *Lycea*, economical administrative schools, and Technical-Vocational Schools.

Programs generally last 5 years, with pupils aged from 14 to 18.

5.1.4. Spain

No information given.

5.1.5. U.K.

The structure of state maintained educational establishments is shown in Figure 3.

56% of children under 5 attend nursery classes.

These are usually available from 3 years of age but are charged for. Free compulsory primary education begins in the year the child is 5 years old.

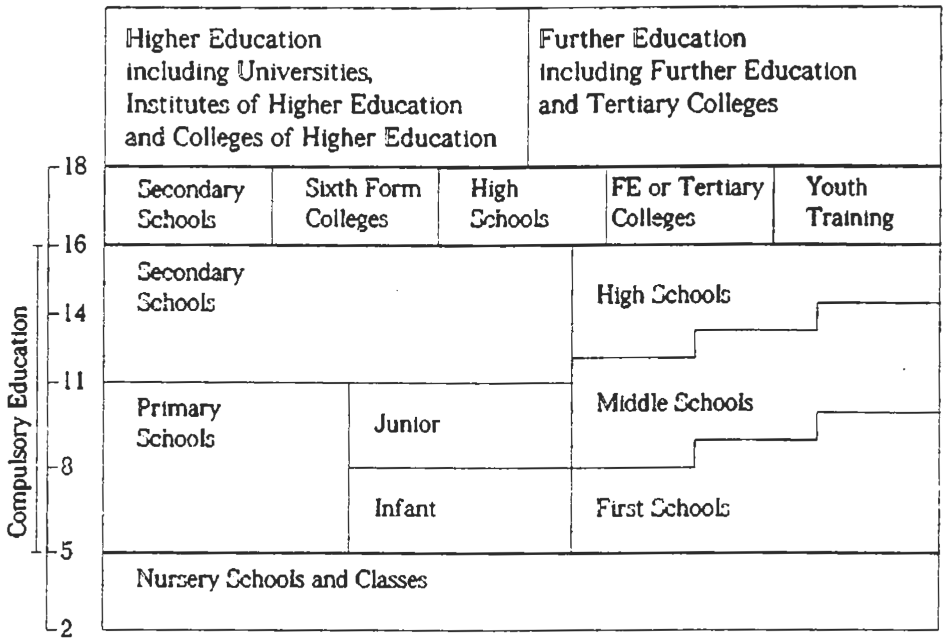
The National Curriculum was introduced for primary and secondary education in 1988 with the Education Reform Act.

More recently Vocational Qualifications known as GNVQs have been introduced into secondary schools and colleges of further education which are roughly comparable with the traditional academic qualifications and there is now the possibility of movement between academic GCSE and GCE A level and vocational GNVQ subjects or of combining the two whilst at school.

Post-16 qualifications can be taken on either a full or part time basis.

There are also vocational qualifications known as NVQs which are of the same standard as GNVQs but are substantially workplace based with part time attendance at a college of further education.

Figure 3 - Structure of Education in U.K.



1. Two tier (*primary* and *secondary schools*) and three tier (*first, middle* and *high schools*) systems exist side by side according to the provision within each individual *LEA* (*local education authority*).

2. Classes for pupils over 16 are known as the *Sixth Form*. 11 to 16 schools are combined with Sixth Form or *Tertiary Colleges* for pupils over 16. Pupils may also transfer to a *Further Education (FE) College*. The Sixth Form College caters exclusively for those aged 16 to 19 and is subject to Schools Regulations. The *Tertiary College* shares characteristics of both the *Sixth Form* and of the *Further Education College*, and is subject to *Further Education Regulations*. All three offer a range of academic and vocational courses.

3. *Youth Training* is delivered through contracts with independent training providers (often private employers). It lasts two years, and is organised in "units of competence".

There are 71 universities and 49 colleges of higher education catering for 950,000 post-18 year old full time equivalent students.

There are 462 colleges of further education and 100 sixth form colleges which together cater for some 2 million students equating to about 800,000 full time equivalent students. This is therefore one of the largest sectors of education and there are a large variety of both academic and vocational courses.

5.2. School population

In recent years a continuous decline in the number of pupils has been reported in all countries, not considering universities.

The general situation, recorded in the five countries, is reported in Figure 4.

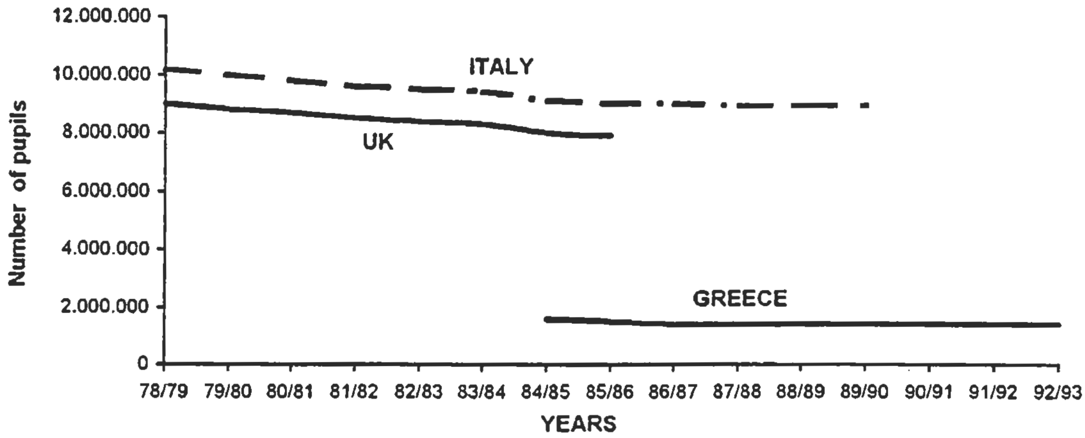
The trend is different for the three components of school population, according to the age of pupils:

- Elementary school
- Primary school
- Secondary school

For each country, when available, a break-down is given showing the variation of the number of pupils with time.

The number of students affects the number of schools and teachers required. The need for new schools is being reduced, and in many countries the best of existing schools are properly retrofitted and refurbished, closing the oldest and least usable ones.

Figure 4 - Variation of the number of pupils



5.2.1. Austria

No information given.

5.2.2. Greece

The number of pupils and their variation in the years is shown in Figure 5, which reports a breakdown of the five components of school population here considered.

5.2.3. Italy

The number of pupils and their variation over the years is shown in Figure 6, which reports a

Figure 5

Variation of the number of pupils in Greece considering various types of schools

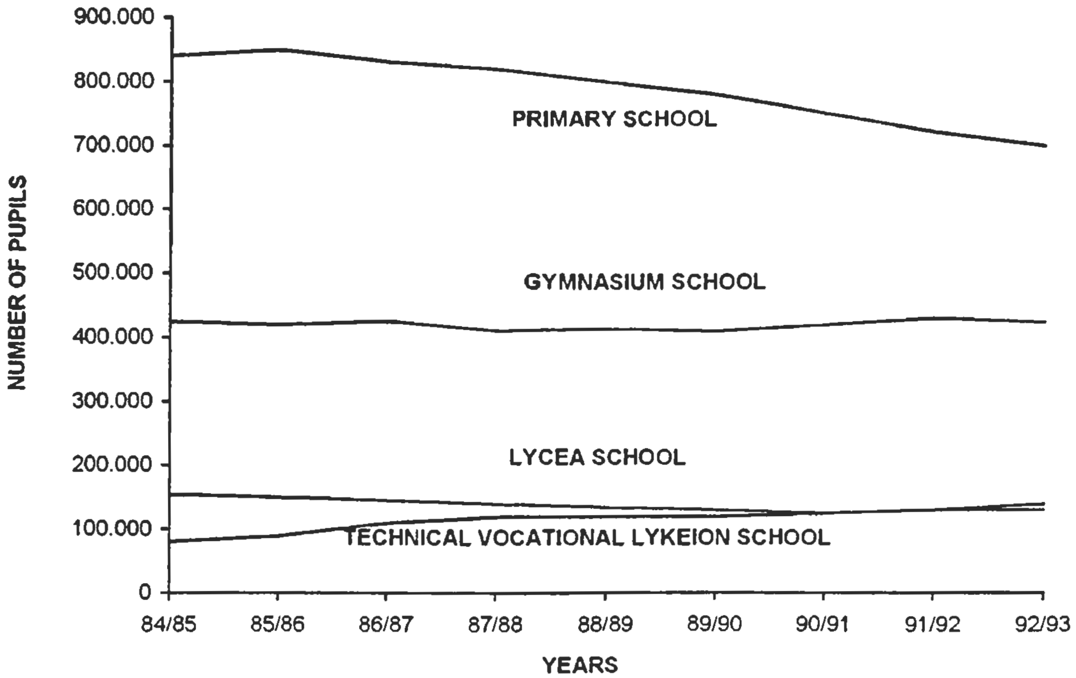
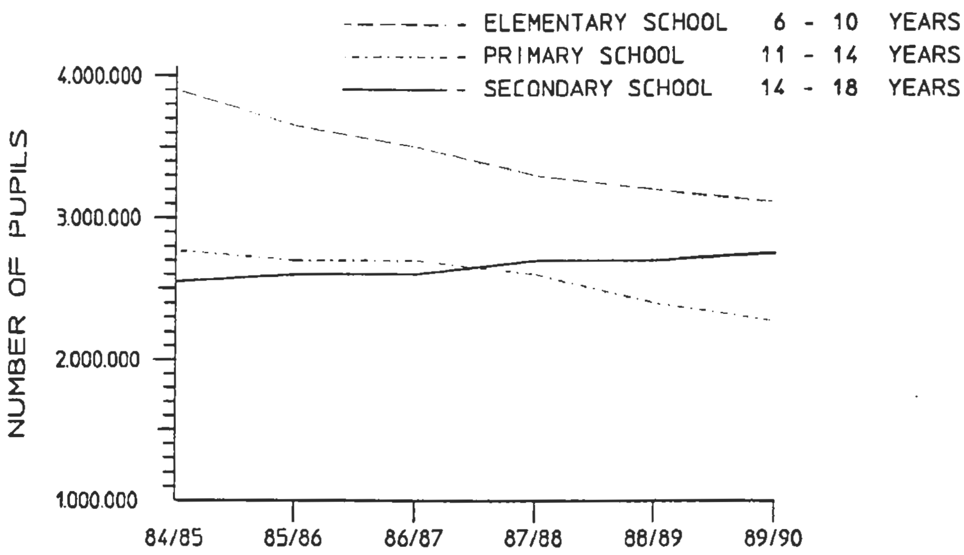


Figure 6



Variation of the number of Pupils in ITALY considering various types of Schools

break-down of the three components of school population here considered.

There is a general reduction in the number of pupils for all kinds of schools, except secondary school, where there is a slight increase. The overall combination of the three components gives a general reduction over time.

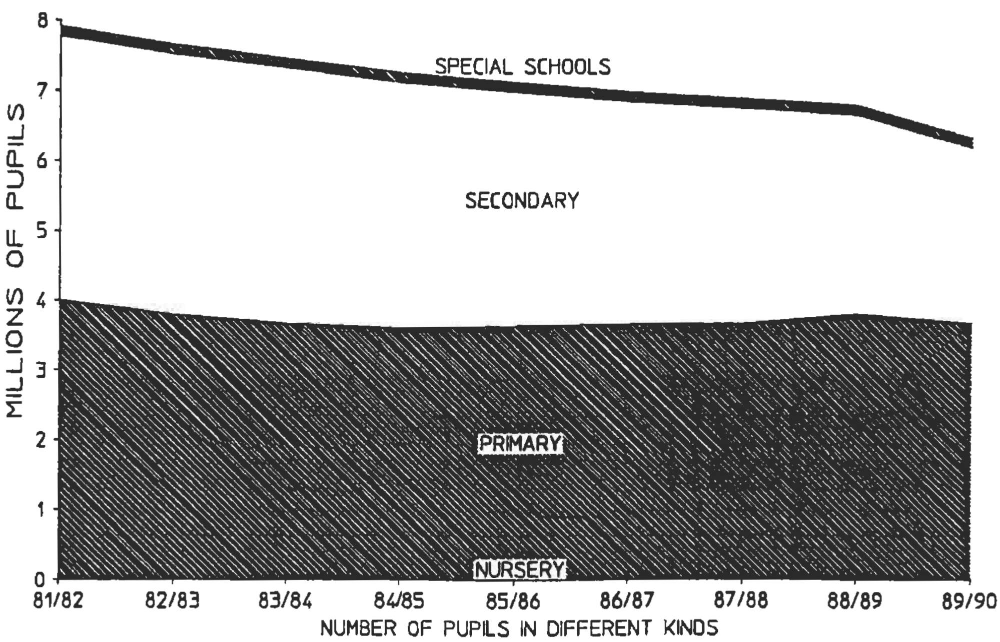
5.2.4. Spain

No information given.

5.2.5. U.K.

The number of pupils in the different kinds of schools is reported in Figure 7.

Figure 7



NUMBER OF PUPILS IN DIFFERENT KINDS OF SCHOOLS IN U.K.

5.3. Administration

Schools are administered in very different ways, from country to country; and in the same country, sometimes, according to the different kinds of school.

Some differences recorded in the five countries are here reported.

5.3.1. Austria

No information given.

5.3.2. Greece

The flow of maintenance funds for school buildings and systems is reported in Figure 8 with an indication of the bodies which undertake the maintenance works.

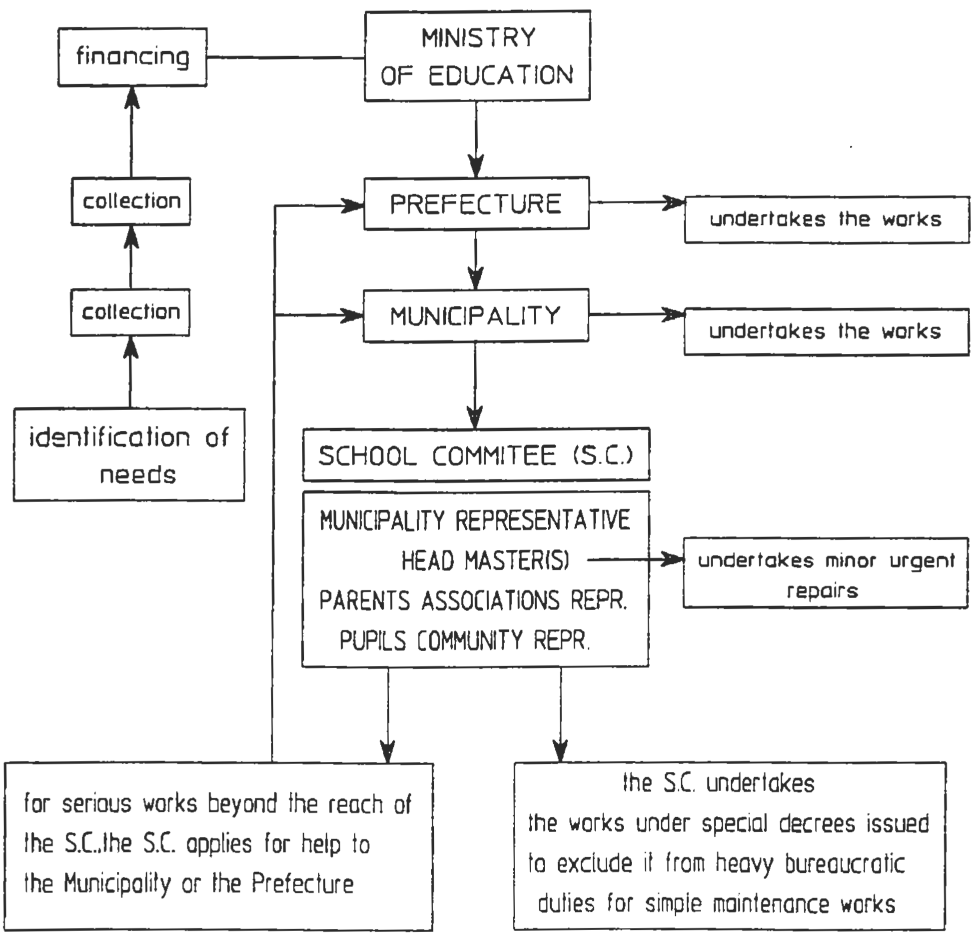
5.3.3. Italy

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

The ownership of the schools is more articu-

Figure 8

Flow of maintenance funds for school buildings in Greece. Bodies undertaking the maintenance works.



lated:

- schools of arts (licei artistici) belong directly to the State;
- scientific high schools (licei scientifici) and administrations (Province or Regioni);
- all other schools (nursery, primary, secondary, high schools) are owned by local municipalities.

The owners are responsible for operation and maintenance expenses.

5.3.4. Spain

No information given.

5.3.5. U.K.

In U.K. the responsibility of administration of educational buildings, and systems is usually committed to the Local Education Authorities (LEA). However schools now have the option to become Grant Maintained and to receive funding direct from Central Government via the Funding Agency for Schools.

The LEA is part of the Metropolitan Borough or County Council which is responsible for provision of nursery (optional), primary and secondary education in its area. Typically, a large County Council might be 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.

5.4. School days

The situation concerning school days during the year, holidays and vacations, number of school hours during the week, etc. is different in the five participating countries.

5.4.1. Austria

No information given.

5.4.2. Greece

• School days:	8 months
• School days in the winter season:	5-6 months
• Summer vacation (days):	90
• Christmas vacation (days):	15
• Easter vacation (days):	15
• Mean length of school days (hours):	
• Is Saturday school day or holiday?	holiday

5.4.3. Italy

• School days:	210
• School days in the winter season:	140
• Summer vacation (days):	70
• Christmas vacation (days):	10
• Mean length of school days (hours):	6
• Is Saturday school day or holiday?	school day

5.4.4. Spain

No information given.

5.4.5. U.K.

• School days:	195
• School days in the winter season:	160
• Summer vacation (days):	6 weeks
• Christmas vacation (days):	2-3 weeks
• Easter vacation (days):	2-3 weeks
• Total vacation (weeks/year):	12 weeks
• Mean length of school days (hours):	7 h
• Is Saturday school day or holiday?	holiday

6. ENERGY USE

The main data concerning energy use and consumption in the five countries are reported with details of the consumption in the school sector; some elements concerning pollution level are also included.

As a general comparison indication, recorded unit consumption of energy in several types of school is U.K. is reported in Table 2.

When the measured energy consumption in a school is lower then values reported in column **A**, it may be considered **low consumption**: when the consumption is between **A** and **B**, we have **medium consumption**; and when it is higher than **B**, it is **high consumption**.

6.1. Energy consumption

Table 3 reports the total energy consumption, in all sectors, in each country, from 1985 to 1991.

For each country are here reported general data concerning energy use and consumption referred to 1991: data are given in **Mtoe** (Mega tons oil equivalent) and in **kgoe** (kilograms oil equivalent).

6.1.1. Austria

- total energy consumption 27 Mtoe
- energy consumption per capita 3,414 kgoe

6.1.2. Greece

- total energy consumption 22 Mtoe
- energy consumption per capita 2,130 kgoe

6.1.3. Italy

- total energy consumption 153 Mtoe
- energy consumption per capita 2,655 kgoe

Table 2

ENERGY CONSUMPTION
Performance Assessment

	A [kWh/m²]	B [kWh/m²]
Primary or middle school		
Fossil fuels	137	189
Electricity	20	27
Secondary school without swimming pool		
Fossil fuels	151	204
Electricity	22	31
Secondary school with swimming pool		
Fossil fuels	172	221
Electricity	26	33

Table 3

GROSS ENERGY CONSUMPTION: Mtoe

COUNTRY	1985	1986	1987	1988	1989	1990	1991
AUSTRIA	23	23	24	23	24	25	27
GREECE	17	17	18	19	21	21	22
ITALY	132	134	141	143	150	152	153
SPAIN	70	71	73	80	83	86	90
U.K.	204	208	209	210	212	212	217

6.1.4. Spain

- total energy consumption 90 Mtoe
- energy consumption per capita 2,321 kgoe

6.1.5. U.K.

- total energy consumption 217 Mtoe
- energy consumption per capita 3,773 kgoe

7. REGULATIONS AND STANDARDS

In this chapter are reported some available data about regulations and standards effective in the five countries, concerning design and operation of school buildings and systems.

7.1. Winter design temperature

The five countries have different geographical location, and consequently we find different climate conditions: the winter design temperatures considered in national standards for the calculation of heating systems are here reported, for all participating countries.

7.1.1. Austria

The winter design temperature ranges from -10 °C to -18 °C, according to the geographical position of the site considered. For Vienna the design temperature is -14 °C.

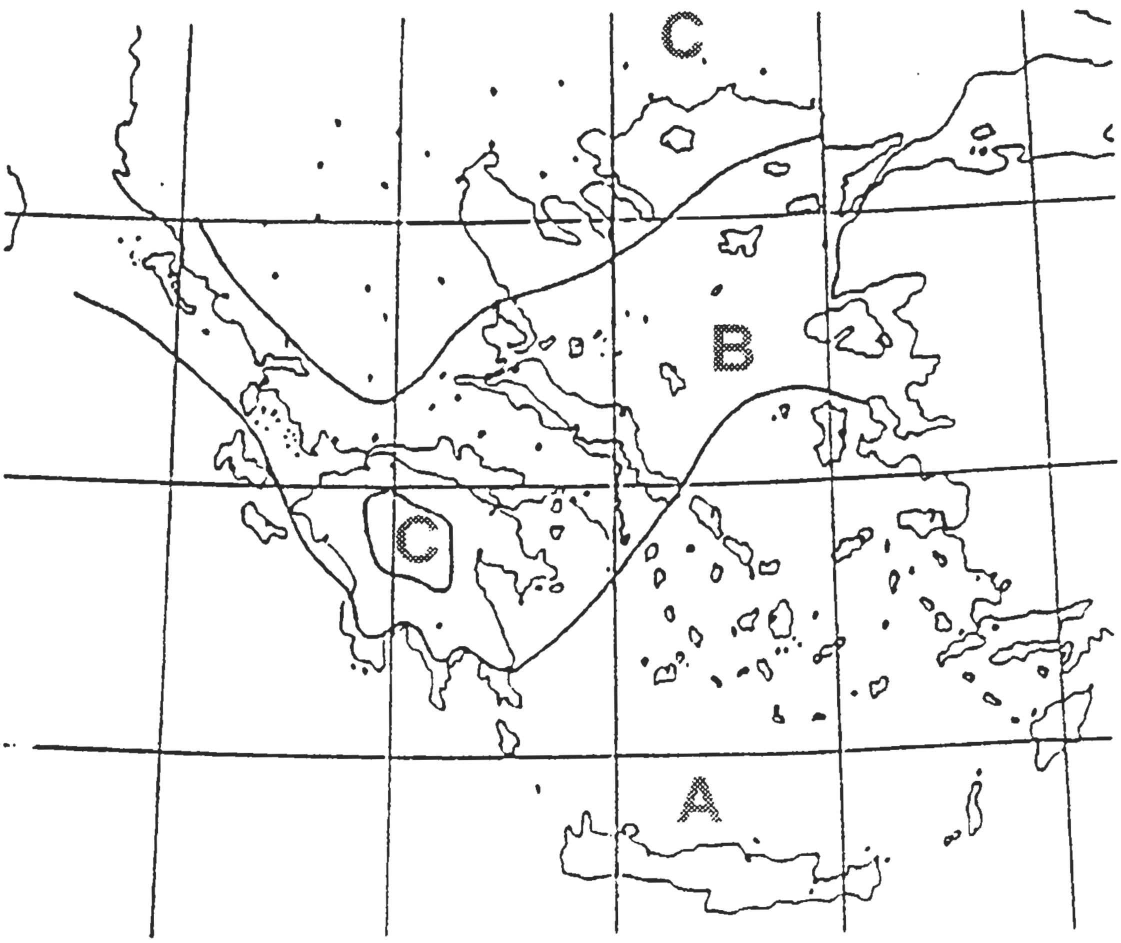
As for heating days in the winter season and design temperature values we have the following average situation.

Zone	Design temperature [°C]	Heating day [d]
-	from -10 to - 18	200-220

7.1.2. Greece

The country is divided into three "climatic zones", A, B and C (Figure 9); each one has a different value of minimum design temperature, also related with the altitude above sea level.

Figure 9



The base temperature for calculating Degree Days in Greece is 18.3 °C.

Zone	Design temperature [°C]	Heating days [d]
A	+5 to + 9	60
B	-3 to + 1	150
C	-12 to -5	210

The average minimum external temperature ranges widely from +5 °C in Southern Crete to -12 °C in the Northern area.

To estimate the duration of the heating period the criterion was the number of days in which the average daily air temperature drops below +10 °C.

Areas higher than 600 m above sea level will be classed in the colder zone, which comes next in sequence after the zone of the considered area.

7.1.3. Italy

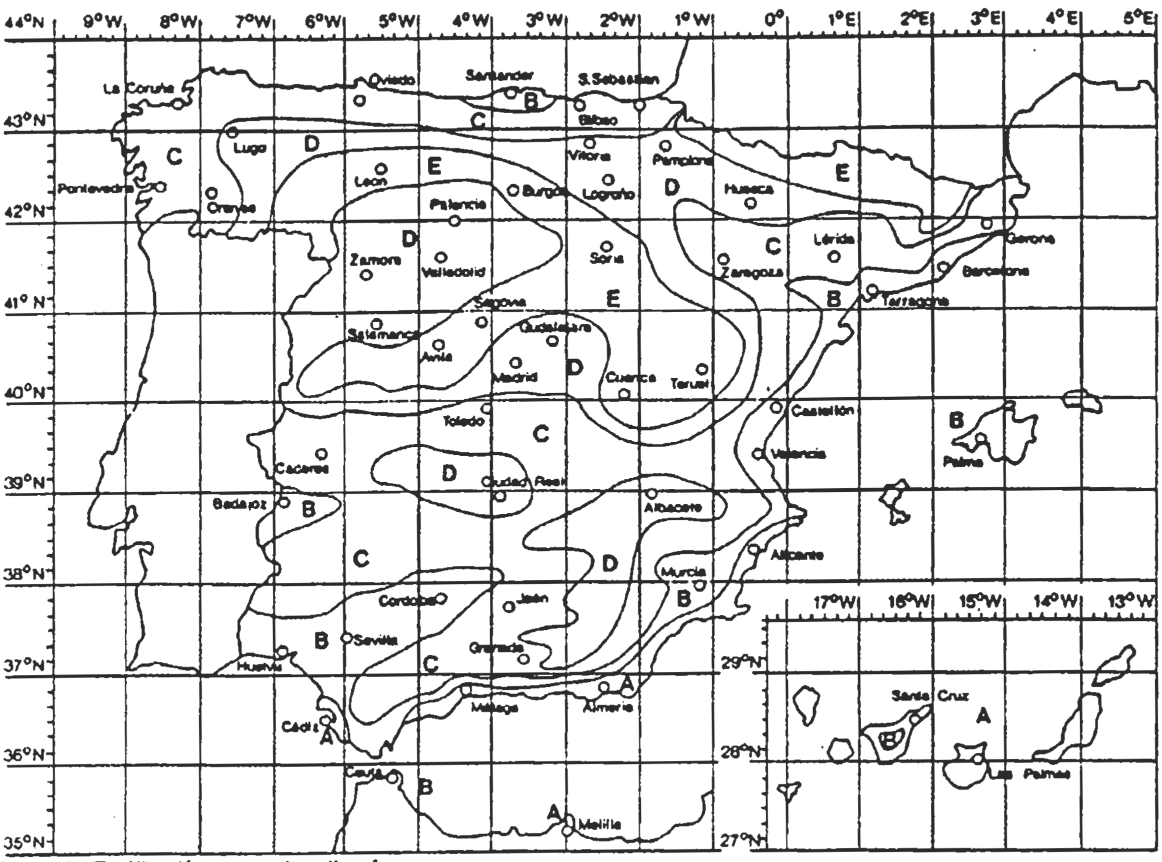
Italy has a north continental area and a long "boot" extending south into the Mediterranean sea.

The whole country 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 Design Degree Days in Italy is 20 °C.

Zone	Design temperature [°C]	D.D. [°C·d]	heating days
A+B	+2 ÷ +5	< 900	120
C	0 ÷ +2	901 ÷ 1,400	150
D	-3 ÷ 0	1,401 ÷ 2,100	160
E	-15 to -3	2,101 ÷ 3,000	180
F	-20 ÷ -15	>3,000	240

Figure 10



Mapa de Zonificación por grados día año

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

Generally speaking, in order to make mean-ing-ful comparisons with the situation existing in other countries, it is better to take separate figures for three different situations:

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

7.1.4. Spain

There are 5 climatic zones, as reported in the following table.

Zone	D.D. [°C·d]	Heating hours
A	≤ 400	< 500
B	401 ÷ 800	501 ÷ 750
C	801 ÷ 1,300	571 ÷ 1,130
D	1,301 ÷ 1,800	1,131 ÷ 1,230
E	> 1,800	1,230 ÷ 1,300

The base temperature for calculating Degree Days is 15 °C.

The distribution of the five zones along Spain territory is reported in Figure 10.

The winter external conditions to consider in the design of heating systems are those corresponding to 97.5% of the total amount of hours in December, January and February, as an average of the last 20 years.

7.1.5. U.K.

As an island, U.K. has a remarkable uniform distribution of temperature.

From a calculation 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. [°C·d]	heating days
-	-1	2,231	

The base temperature for calculating D.D. in U.K. is 15.5 °C.

7.2. Lighting

Lighting levels specified in schools, according to national standards, are the following.

7.2.1. Austria

	[lux]
• Classrooms	300
• Circulation areas	100
• Sport areas	200-400
• Workshops	300

7.2.2. Greece

	[lux]
• Classrooms	300-325
• laboratories	300-325
• Circulation areas	150
• Auditorium	300-325
• Library	500-540
• Offices	300-325
• WC	250
• Sport areas	200-400
• Medical	300

7.2.3. Italy

	[lux]
• Classrooms	300
• Circulation areas	100
• Sport areas	200
• Workshops	300
• Medical	
• Others	

7.2.4. Spain

	[lux]
• Classrooms	300-500
• Circulation areas	125-150
• Sport areas	150-300
• Auditorium	200-500
• Laboratories	200-500
• W.C.	150

7.2.5. U.K.

	[lux]
• Classrooms	300
• Corridors, stairs	100
• Entrance halls, Lobbies	200
• Areas with visually demanding tasks	500

7.3. Winter internal design temperature

In all countries, national standards require different levels of internal temperature, also varying with the type of room.

7.3.1. Austria

	[°C]
• Classrooms	20±2
• Circulation areas	15
• Medical	24
• Sport areas	16
• Workshops	20

7.3.2. Greece

	[°C]
• Classrooms	+20
• Laboratories	+15 to +18
• Circulation areas	+5 to +10
• Auditorium	+18
• Library	+20
• Offices	+20
• WC	+5 to +10
• Sport areas	+15
• Medical	+24

7.3.3. Italy

	[°C]
• Classrooms	20±2
• Circulation areas	20±2
• Sport areas	20±2
• Workshops	20±2
• Medical	20±2

7.3.4. Spain

	[°C]
• Classrooms	20
• Circulation areas	17
• Sport areas	15
• Auditorium	17
• Offices	20

7.3.5. U.K.

	[°C]
• Classrooms	18
• Circulation areas	15
• Sport areas	15
• Workshops	15
• Medical	21

7.4. Design ventilation requirement

These requirements are given in different units: in certain countries air flow is expressed in cubic meters per hour, while in others air flow is expressed in air changes ("*volumes*") per hour (V/h) or litres per second.

7.4.1. Austria

These requirements are given in air changes per hour.

	V/h
• Classrooms	2
• WC	4 to 6
• Sport areas	2.5

7.4.2. Greece

These requirements are given in air changes per hour.

	V/h
• Classrooms	5
• Laboratories	5
• Circulation areas	
• Auditorium	3.5
• Library	5
• Offices	5
• WC	5
• Sport areas	4

7.4.3. Italy

	V/h
• Air changes per hour:	
(Primary school)	2.5
(Middle school)	3.5
(Secondary school)	5.0

7.4.4. Spain

- Air per person per hour [m^3/h pupil]:

• Classrooms	18-25
• Laboratories	18-25
• Conference Hall	9-13
• Library	13-18
• Dining rooms	18-29

When the air ventilation flowrate exceeds ONE air change per hour, installation of energy recovery systems is compulsory.

7.4.5. U.K.

- Background ventilation 3 litres/sec. pers.
- Rapid ventilation: 8 litres/sec. pers.

7.5. Heat loss from the building fabric

7.5.1. Austria

- Vertical external walls: K = 0.5 W/m²K
- Roofs: K = 0.5 W/m²K
- Earth touching walls: K = 0.67 W/m²K
- Earth touching floors: K = 0.47 W/m²K
- Window glazing: K = 2.10 W/m²K

7.5.2. Greece

- Vertical external walls: K = 0.7 W/m²K
- Roofs: K = 0.5 W/m²K

Floors over non - heated areas:

ZONE A K = 3.0 W/m²K
ZONE B K = 1.9 W/m²K
ZONE C K = 0.7 W/m²K

Walls next to non - heated areas:

ZONE A K = 3.0 W/m²K
ZONE B K = 1.9 W/m²K
ZONE C K = 0.7 W/m²K

The highest rated average transmittance coefficient U (W/m² · K) as function of aspect Ratio F/V considering the envelope surface of the building **F** (m²) and its volume V (m³) is reported in Figure 11, for the different three mentioned Zones A, B, C.

7.5.3. Italy

In Italy, according to present regulations, the transmittance coefficient "U" (W/m² · K) for opaque areas is a function of the mass "M" (kg/m²) of the structure considered, as shown in the following table:

Vertical external walls

M [kg/m²]	20	50	100	≥200
U [W/m²·K]	0.37	0.53	0.7	0.93

Roofs

M [kg/m²]	100	200	≥300
U [W/m²·K]	0.5	0.70	0.86

7.5.4. Spain

Maximum allowed values of heat transfer factors (W/m² · K) are a function of the mass of the structure considered (kg/m²) and of **climatic zone**, as shown in Table 4.

Figure 11

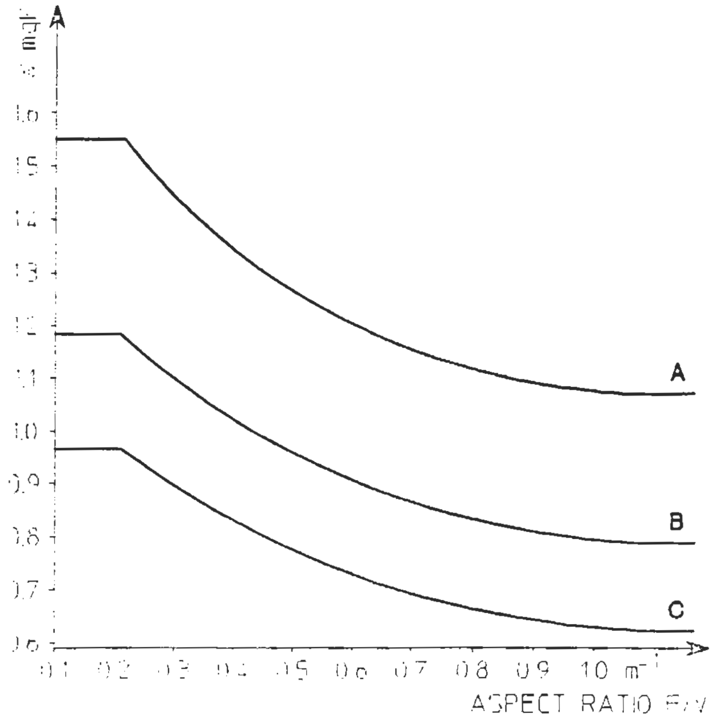


Table 4

Type of structure		Climatic zone (see map)			
		A&B	C	D	E
external structures	roofs	1.40	1.20	0.90	0.70
	light facades (≤ 200 kg/m²)	1.20	1.20	1.,20	1.20
	heavy facades (> 200 kg/m²)	1.80	1.60	1.40	1.40
	wrought over open spaces	1.00	0.90	0.80	0.70
Structures in non heated rooms	Partitions	2.00	1.80	1.60	1.60
	floors	---	1.40	1.20	1.20

7.5.5. U.K.

In U.K. the average thermal transmittance coefficients should not be greater than the following:

Walls	0.4 $W/m^2 \cdot K$
Floors	0.4 $W/m^2 \cdot K$
Roof	0.3 $W/m^2 \cdot K$

Windows:

Single Glazing	4.1 $W/m^2 \cdot K$
Double Glazing	3.3 $W/m^2 \cdot K$

7.6. Area per pupil

7.6.1. Austria

No information given.

7.6.2. Greece

The situation is explained below.

Number of classrooms	Number of pupils	Area [m^2/pupil]	
		Building	Building + yard
NURSERY			
1	30	8.76	39.00
2	60	6.36	24.00
PRIMARY			
3	90	7.93	21.00
6	180	7.22	15.00
9	270	6.37	12.00
12	360	5.70	11.00
SECONDARY			
6	210	8.49	16.00
9	315	7.58	14.00
12	420	6.62	12.00
15	525	5.90	11.00
18	630	5.86	10.00

7.6.3. Italy

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	---

7.6.4. Spain

No information given.

7.6.5. U.K.

Area required for primary and secondary schools are under revision. For more information contact Architect and Building Division of the Dept for Education.

The area per pupil generally decreases with increasing pupil number in School.

7.7. Temperature of Domestic Hot Water (D.H.W.)

In the five countries, there are different standards and regulations for the maximum temperature of D.H.W.

7.7.1. Austria

The normal temperature for hot water is 45 °C, with a maximum allowable of 50 °C.

7.7.2. Greece

Hot water is generally not available in schools.

7.7.3. Italy

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

There is a limited usage of hot water in schools.

7.7.4. Spain

Domestic Hot Water (D.H.W.) may be prepared at maximum temperature of 58 °C, and may be distributed at 50 °C.

In Educational buildings the maximum temperature of the hot water circulating in the pipework shall be 42 °C, provided that the water is used only for showers, sinks, etc.

7.7.5. U.K.

Limit temperature for domestic hot water, in U.K., for baths and showers, in schools, is 43.5 °C.

7.8. Electrical energy

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

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 consumption of electricity in school buildings in the five participating countries is here reported: consumption data are measured in kWh electrical and given in kWh/m^2 per annum and kWh/pupil per annum, for different kinds of schools, according to available data, in the various countries.

7.8.1. Austria

No information given.

7.8.2. Greece

No information given.

7.8.3. Italy

	kWh/m$^2 \cdot$ a	kWh/pupil $\cdot$ a
• elementary schools:	9.9	94.3
• primary schools:	10.2	96.3
• secondary schools:	13.3	115.0

7.8.4. Spain

No information given.

7.8.5. U.K.

	kWh/m$^2 \cdot$ a	kWh/pupil $\cdot$ a
• elementary schools:		
• primary schools:	25	175
• secondary schools:	23	240

PART TWO - SEMINARS

8. ORGANISATION OF SEMINARS

During three year activity of the Working Group, six Seminars have been organised in turn by the five participating Countries, on selected topics concerning school design and energy management.

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

The list of Seminars, was as follows:

- ***Ventilation and indoor air quality in educational buildings*** - Rome, May 28, 1992
- ***School and environment*** - Vienna, October 3-8, 1992
- ***Rational utilisation of energy resources, environmental impact, conservation in educational buildings*** - Madrid, May 6, 1993
- ***Bioclimatic school architecture*** - Athens, December 2, 1993
- ***Designing educational & recreational buildings with energy in mind*** - Cambridge, May 5, 1994
- ***Improving energy efficiency in educational buildings*** - Milano, December 1, 1994.

8.1. Ventilation and indoor air quality in educational buildings

Seminar held in Rome , 28 May, 1992. Papers presented to the seminar:

- **S. PIARDI**, Polytechnic of MILANO
  Building Products and environmental qualities
- **M. PATEL**, Department of Education and Science, London
  Ventilation in U.K. Schools. An Overview
- **P. GATTERMANN**, Austrian Institute for Schoolbuilding and Sportfacilities - OISS, VIENNA
  Research work about room-climate in Austrian Schools
- **M.T. PORFIRI**, Energy Department, ENEA, Rome
  Standards for air changes in educational buildings. Energy cost of air quality and measures for its reduction
- **F. TREVISAN**, Azienda Servizi Municipalizzati, Vicenza
  Air changes in the frame of a project of energetic requalification of an educational building complex, in the town of Vicenza
- **M. CALI'** Polytechnic of TORINO, Energy Department
  Study of the gas mixture flows in confined spaces using inverse problem theory
- **R. BORCHIELLINI**, Polytechnic of TORINO, Energy Department
  The new automated apparatus of the Polytechnic of Torino for tracer gas measurement
- Ministerio de Educacion y Ciencia; Ministerio de Industria y Energia, Madrid
  Programma de optimizacion de cuestos energeticos en los edificios e instalaciones del ministerio de Education y Ciencia en España
- **G. SCIOCCHETTI**, Environment Department, ENEA, Rome
  "RADON": a potential source of indoor air pollution. EPA approach in educational buildings

The Seminar was organised in Rome by ENEA, FIRE and the Working Group, with the intention of making an analysis of the problem of ventilation, and associated losses.

Eleven reports where presented: one from U.K., one from Austria, two from Spain, seven from Italy, concerning the several aspects of the problem, with an attendance of some 80 persons.

Ventilation represents a significant share of the losses in a school building, therefore a special attention should be given to this item when we consider the possibility to reduce the energy consumption in this type of building.

Other losses are a consequence of poor insulation, and of the reduced efficiency and/or improper use of heating and electric systems, which includes design, installation, operation and maintenance of such systems.

While all other losses due to heat transfer or to inefficient operation may be reduced by means of suitable actions aimed to increase the thermal resistance of outside walls, windows, roof, etc., and to improve the management of the system, the losses associated with ventilation are proportional to the air change rate, which depends on health regulation and indoor air quality standards.

8.1.1. Ventilation

In any type of building the purpose of ventilation is to provide sufficient fresh air for occupants and to dissipate unpleasant odours, excessive humidity and heat and limit the concentration of substances which can be present in the air.

Ventilation has a significant importance for school buildings, where young people spend a considerable part of the day.

Ventilation requirements in school buildings are considered in specific standards in all countries, which prescribe minimum air change rates, as well as rules for design and operation.

The problems with Natural Vs. Mechanical Ventilation in Schools have been considered in many papers presented to this Seminar, pointing out the differences existing among requirements in different countries, as well as the benefits and drawbacks of all kind of ventilation systems, whose general objectives are:

- limitation of energy consumption;
- better respect for the environment;
- increased quality of indoor conditions.

Schools are very different from offices, from homes and other types of buildings, in the way they are used.

Classroom doors are opened much more frequently than in a lot of other spaces: there are changes between the periods when whole classes will go out and come in, so the door is open for a long time. There are also breaks and recesses, so again the doors open and close, and there is opportunity for air in the classrooms to get flushed out: that is why natural circulation seems to work.

8.1.2. Indoor air quality

A building is a complex thermodynamic system, where the air flow movement, with its content of airborne particles, plays a central role for many reasons, the most important being the contribution to the energy consumption and to the occupants comfort and safety.

Indoor air quality (I.A.Q.) is determined by a combination of thermal conditions, air changes and movement, pollutant level, and it is strictly related both to energy conservation and to environment protection.

An acceptable room air quality is said to be at hand if no more than **X%** of the occupants are dissatisfied. The value of **X** varies from 5 to 20 depending on the researchers' point of view and the types of person group involved. If the number of dissatisfied people exceeds 20% then some remedial action is highly recommended, including increase of air change rate, improved filtering of outdoor air, local exhaust air terminal devices, etc.

Air quality within the school is dependent on the level of different permanent pollutants; indoor climate factors such as extremely dry air, or air contamined by micro-organism, dust, toxic fumes; gases or annoying smells also produce discomfort.

Indoor air can be highly contaminated with both organic and inorganic chemicals caused by emission from furniture, floors, and other surfaces, as well as by pollutants in the outdoor air. New building materials emit pollutants to a greater extent then older ones: therefore a larger air change rate can be required in new buildings. Air humidity and air exchange are the factors which exert the most significant influence on the chemical concentration in room air.

A study has been performed in Austria with the purpose to record the daily course taken by the indoor climate in structurally different classrooms, to try to suggest possibility of influencing the air humidity in classrooms by way of modified behaviour regarding airing and heating, and to evaluate the impact exerted by the building as such.

Considering the great variability in the composition of products and in their use, the demand of useful and plain information about environmental and health related performance of building products is quickly increasing, requiring the solution to many new problems.

An extended research work is in progress in Italy directed to identify and evaluate the relationship existing between materials and environment.

When we consider the concept of air quality, the evaluation and measurement of air flowrate and pollutant contents are of primary importance.

The problems related to quantitative evaluation of the velocity field of a two-phase mixture composed by the clean air and the gaseous and particle contaminants in a multi-zone building have been examined by another University Laboratory in Italy, with an extension to the analysis of the temperature field.

8.2. Educational buildings and the environment

Seminar held in Vienna, October 2-8, 1992. Papers presented to the Seminar:

- **A. ABEND**
  Indoor air quality: Maryland Public Schools, U.S.A.
- **H.J. BLOEDOW**
  Improving the energy characteristics of school building in the new federal Länder
- **A. CASTRO RIAL GARRONE**
  Schools and their different sitings in the Spanish landscape
- **B. COLD**
  Indoor recreational places as glazed space
- **F. GARCIA PAREDES**
  Guidelines for a healthy educational environment
- **E. GRAF**
  Recycling
- **J.R. KLEBERG**
  Quality learning environments
- **R. LAZZERINI**
  Ventilation and indoor air quality in educational buildings
- **E.F. LEBLEBICIOGLU; E.FIGEN**
  School and Environment
- **B. LUCAS**
  The value of learning through landscapes
- **I. NESVADBA**
  Energy policy in school buildings: reality trends and fiscal measures
- **P. OBADALEK**
  Behaglichkeitsmessungen in einer Klasse der Bundeshandelsakademic in Laa an der Thaya und des BRG XXIII in Wien sowie Vergleich der Ergebnisse
- **M. PATEL**
  Energy efficient schools in UK
- **P. POSCH**
  Umweltinitiativen an der Schule
- **G.W. REINBERG**
  Passive use of solar energy in ecological school construction
- **C. RITTELMEYER**
  Healthy schools
- **G. SCHINDLER**
  Schule und Umwelt
- **R. TAPANINEN**
  Healthy schools: some factors of a healthy school environment
- **R. WOLF**
  Health-threatening building materials in school construction and equipment

This international seminar was held in Vienna, organised by the OECD Programme on Educational Building (PEB) in co-operation with the Austrian Ministry of Education and Art and the Austrian Institute for School and Sports Facilities with participation of the IEA Working Group on Energy Efficiency in Educational Buildings, with the intent to identify how educational building can contribute to the conservation and protection of the environment.

About 70 participants from 20 countries attended the seminar; they brought together a wide range of expertise and represented a rich variety of the educational systems.

The issues discussed are presented under three headings:

- healthy schools;
- green schools;
- energy-conscious schools.

8.2.1. Healthy schools

Good health is of paramount importance to the individual and to society.

The claim that "a well-designed school is a healthy school" not only makes common sense, but has been substantiated in surveys carried out among school children and through research: feeling good and keeping healthy at work depend to a considerable extent on the building one occupies.

Important contributory factors to a feeling of well-being are the external appearance of the building, the proportions and layout of rooms, the materials used in construction, the colour scheme, natural and artificial lighting, indoor climate and acoustics.

Every opportunity should be used in new buildings and during maintenance and renovation work on existing buildings to improve the quality of facilities, to use local, environmentally friendly and safe materials, and to aim for solutions which minimise the consumption of raw materials.

A clear layout and a warm, pleasant environment inside the school should be regarded as minimum requirements. Surveys carried out amongst pupils have established that the architecture of school buildings has to meet certain basic social needs. Pupils react to their surroundings and use a wide range of adjectives to describe different facilities: cold, characterless, uninspiring, aggressive, warm, soft, oppressive, liberating, friendly, inviting, attractive, showy, protective, and so on.

Heavy, oppressive ceilings on weak-looking pillars should be avoided, as should aggressive gloss paint, the juxtaposition of unrelated colours and shapes, sharply drawn boundaries and spaces without windows. Wide vistas, light-toned varnishes, markings pointing the way into the premises and the merging of structural elements in warm colours are all desirable for a healthy school.

8.2.2. Green schools

Few would dispute that schools should be healthy places but the notion of a "green" school is less widely recognised. However educational institutions, especially schools, provide a uniquely influential opportunity for environmental education. The building in which children spend a substantial part of their early years will have a lasting influence on them. A "green" school is one which is integrated with its environment urban or rural in such a way that children can have contact with nature, and can begin to understand some of the issues involved in environmental education.

The use and layout of external areas, school yards, recreation areas and school gardens, should make it possible to observe the changing seasons and should provide opportunities to observe the life-cycle of plants and animals.

The OECD's Centre for Educational Research and Innovation is engaged in a project on "Environment and school initiatives". Among other aspects of environmental education it addresses the issue of student awareness.

Very few schools are situated in environments which naturally lend themselves to a study of nature and the environment. Many have restricted sites, and even where substantial areas of land are available these are frequently devoted to sport.

However pioneering work has been carried out in the United kingdom to increase public awareness of the potential of school grounds.

The nature of the school environments varies both within countries (urban and rural; different climatic conditions) and between countries (some provide extensive grounds, others do not). Although it is not possible to prescribe solutions it is worth noting that school grounds present an opportunity for environmental and others studies on which many schools are failing to capitalise.

Wherever man intervenes in nature, for example to build a school, he contributes to the destruction of the natural environment. The simple possibilities of using the ground to improve working conditions for teachers and pupils and to establish the school as an example of how human activity can protect and enhance the environment, and contribute to its protection, are of great potential value.

8.2.3. Energy conscious schools

Energy conservation should be one of the primary objectives of the management programme of the school.

However, buildings must not become over-technical machines which only specialists are able to understand and whose efficient operation is dependent on high levels of staff, energy and maintenance expenditure. So far as possible the building should be self sufficient. This will mean making optimal use of its location, the availability of sunlight, insulation and thermal capacity, prevailing winds and natural ventilation.

Every kilowatt of energy saved is a contribution to the protection of the environment.

The characteristics of the building shell, the adjustment of services and the minimisation of heat loss through ventilation are the main factors in energy conscious management.

There are two trends in construction to meet these requirements at present: on the one hand massive structures which retain heat and use windows for ventilation and, on the other, light structures with mechanical ventilation and heat recovery in winter. The future will show which of these two systems proves more efficient.

Research has been carried out on heat retention involving measurements of the internal and external environment (ambient temperatures, radiator temperature, inner and outer surface temperatures of the walls, outside air temperature, temperature when the windows are open, when the lights are on or when the blinds are down, relative humidity).

In schools with massive structures, and consequently high heat retention capacity, there is little correlation in winter between outside air temperature and inside air and surface temperatures.

Schools with a lighter structure exhibit strong correlation in summer between inside and outside temperatures.

In principle, natural lighting is to be preferred for classrooms, although there are no precise rules about sunlight and the daylight ratio.

The question arises here of whether priority in the future should go to natural lighting which will imply use of relatively large windows, thus leading to greater heat losses in winter, or to predominantly artificial lighting with small windows or no windows at all, which minimises heat losses in winter and permits the use of compact, energy efficient structures.

The psychological aspect of windows must be taken into account, since it is important to be able to see outside. This necessity can be disregarded only in rooms in which windows disturb teaching e.g., when visual aids are frequently used.

Experience in the last few years has shown that as a rule it is more economic to improve existing buildings and renovate their heating systems than demolish and re-erect them. With improved roof insulation, smaller window areas, blocked-up windows, new burners, new boilers, control systems and replacement of the hot water systems, substantial energy savings can be made.

8.3. Technical meetings on rational use of energy resources and conservation of educational buildings

Seminar held in Madrid, May, 6,7 1993. Papers presented to the Seminar:

- **R. LAZZERINI**
  Activity of International Energy Agency in the school field
- **A. SANCHEZ DE VERA**
  Plan for energy savings and efficiency, part of the national Energy Plan
- **R. BOWEN**
  Energy conservation in Schools: U.K. overview
- **M.T. PORFIRI**
  Investigation on energy consumption in schools in Italy. Use of new technologies and renewable sources
- **J.A. ALONSO MIGUEL**
  Practical recommendations for saving energy in educational buildings
- **P. GATTERMANN**
  Healthy schools
- **O. GARCIA RUBIO**
  The energy costs optimisation program in state administration buildings
- **G. YANEZ**
  Bioclimatic Centre in Guadalayara
- **M.R. MIRO**
  Application of the S.A.V. (Solar-Acoustic-Ventilated) window in a school
- **E. STOURMAS-TRIANTIS**
  Passive solar retrofitting of educational buildings in the Mediterranean: an example from Greece
- **J. GALINDO ANDUJAR**
  Technical management conservation of educational buildings heritage
- **J. LACASA DIAZ**
  Studies on the necessity for conservation and maintenance in educational centres

- **C. ESTRADA**
  Financing of the conservation and maintenance of educational buildings

The seminar has been promoted by the **International Energy Agency** in conjunction with the Educational Construction Programme of the O.E.C.D. and organised by the board of Construction of the Ministry of Science and Education, and by the Institute for Energy Saving and Diversification (I.D.A.E.) of the Ministry of Industry, Commerce and Tourism.

In all reports presented to this Seminar the main problems concerning both energy savings and environment protection in the school sector have been considered.

The rational use of energy is one of the most evident ways of contributing to the resolution of today's main environmental problems.

The various experiences, and the results of the energy conservation measures undertaken in the countries participating in I.E.A. programme have been presented and compared.

Not all measures have been successful; there have been practical difficulties during installation, or secondary problems such as condensation, but knowledge of failures is as good as knowledge of successes. What is a good solution in one situation is not necessarily good in another.

It is essential to find out what others are doing, and calculate if particular measures can be applied in a practical and cost effective manner in the local situation: this is the meaning and the objective of international co-operation.

One of the main problems is not a technical one, and is related to the word: **Responsibility**.

In the cases when the school does not pay directly for the energy used, the problem is overcoming the indifferent attitude of the occupants.

8.3.1. Energy saving opportunities

All countries are facing very similar problems, and the most common energy conservation measures applied in school buildings and systems seem to belong to the following ways:

- altering the physical construction of the building to reduce the heat transfer losses;
- replacing or upgrading the energy consuming equipment, and applying suitable control systems with the aim to increase the efficiency;
- changing or modifying energy consuming equipment to use a less expensive form of energy or more advantageous tariff;
- improving management and maintenance procedures

8.3.2. Results of actions undertaken

Many papers presented to the Seminar reported the results of large scale programmes carried out on school buildings and systems, in several countries.

The procedures implemented may be generally described with the following steps:

- energy prediagnosis: computerised analysis of the energy saving possibilities of each building:
- energy diagnosis, with its optimisation curves for electricity billing, fuel billing, for construction and facilities.
  All actions are supported by specific computer programmes;
- implementation of building and systems renovation, with standardisation of components into packages, for better control and savings.
- follow up of results and regular adjustment of the systems for a check of the results and comparison with the set objectives.

8.4. Bioclimatic schools architecture

The Seminar was held in Athens on December, 2, 1993 organised by the Greek Ministry of National Education and Religious Affairs, with co-operation of the IEA Working Group on Energy Efficiency in Educational Buildings.

Papers presented to the Seminar:

- **E. ANDREADAKI-CHRONAKI**
  Bioclimatic architecture - Planning variables and adjustment of school buildings to energy efficiency and betterment of thermo - optical conditions. GREECE

- **A. CELLIE**
  Survey of the situation existing in school buildings in the Province of Rome, considering energy utilisation. ITALY
- **K. THEODORAKOPOULOS**
  Planning and operation management of university buildings for greater energy saving: the case of the Patras University. GREECE
- **O. GARCIA-RUBIO**
  The rationalisation of bioclimatology based on the use of energy resources and the efficiency of consumer equipment and installations. SPAIN
- **P. GATTERMANN**
  Comfortableness in schools. AUSTRIA
- **G. KALLIGERIS**
  Implementation of bioclimatic architecture in the Crete schools. GREECE
- **P. LIVERIS**
  Implementation of solar energy and natural cooling, in school buildings, in South Europe. GREECE
- **P. LAZZERINI**
  The bioclimatic aspects of the design of a new university library. ITALY
- **M. PATEL**
  Energy efficiency and passive solar school design in England. UNITED KINGDOM
- **E. STOURNA-TRIANTI**
  Passive solar retroplanning in Mediterranean educational buildings. GREECE
- **N. FIDIKAKIS**
  The social dimension of bio-environmental planning in education. GREECE

When the early Greeks oriented their buildings to take better advantage of natural light or to allow air currents to pass through them and to improve their ventilation, they were using ancestral skills which balanced man's basic instinct to protect himself from external threats and his intelligence in analysing the multiple options offered to him by Nature.

With the passage of the centuries, the spread of technology in providing water, electricity and heat and the use of fossil fuels and radioactive materials as a source of primary energy, introduced new concepts in the design and construction of buildings.

With the progress of communication, new construction techniques were diffused amongst neighbouring countries, raising new problems with solutions which are ideally suited to the climate and resources of the country where they originated but have disadvantages in others where energy characteristics are highly dissimilar.

If we take the particular case of school buildings, the results have not always been positive, considering energy consumption and environment protection.

The bioclimatic design of a building is now directed to take the maximum advantage of all natural resources, considering factors such as: orientation of the building, correct location of transparent surfaces, choice of materials, utilisation of solar energy both passive and active, prevailing winds, natural ventilation, natural lighting, interaction with external environment and vegetation, etc.

Besides, the mechanical system should support this design philosophy, giving low energy consumption and preventing development of noise, dust and pollution.

Most of the reports presented to this seminar generally tended to analyse the factors that influence the confortableness in a school.

It is important to define basic parameters which should permit us to identify the actions to be carried out on school buildings and related systems, directed to attain a satisfactory level of performance.

For instance, competitive sports are not possible in a sport hall with a room temperature of 25 °C. In a school class with a temperature of 15 °C pupils can not sit quietly and listen carefully, they will move; no ideal conditions for a class.

From the bioclimatic point of view, the main parameters are the following:

- room temperature;
- relative humidity;
- indoor air quality;
- illumination level;
- noise level;
- security;
- air velocity.

These aspects are interconnected, since human beings tend to feel "hot" and "cold" sensations in response to heterogeneous stimuli, such as nervousness, poor lighting, claustrophobia, and so on, which actually have nothing to do with direct climate control, but should be taken into account in order to achieve comfortable conditions.

The whole facility has to be easy to run and a low energy consumer; this target may be accomplished by:

- taking best advantage of natural resources, in terms of light and heat;
- planning insulation and mass of walls, floors and roofs in order to minimise heat losses (as well as heat gains, in summertime) and to raise the surface temperature for better comfort;
- choosing low consumption components, such as fluorescent lamps;
- recovering heat otherwise lost in ventilation, with air mixing and heat recovery systems;
- using automatic controls to perform complex operations, such as varying the makeup air rate according to room occupancy, so preventing human mistakes or forgetfulness;
- providing a supervisory Building Energy Management System (BEMS), which monitors the actual energy consumption and records useful data, such as running time of mechanical components, making the running and maintenance of all the systems easier.

8.5. Designing educational and recreational buildings with energy in mind

Seminar held in Cambridge UK-5 May 1994. Papers presented to the Seminar:

- **J. WIBBERLEY,** Essex County Council, UK
  New School Building Development Project for Essex County Council, UK
- **P. GATTERMANN**, Austrian Institute for Sports Facilities and School Building, Vienna.
  Energy Saving in Austrian Indoor Pools
- **G. JOHN**, The Sports Council, U.K.
  Energy Matters in U.K. Sports Buildings
- **T. MATTHEWS**, Tim Matthews Associates, Essex, U.K.
  New Campus for Anglia Polytechnic University, Chelmsford, U.K.
- **M. PATEL**, Department for Education, U.K.
  U.K. Guidance Notes for Educational Buildings
- **A. BERTOCCHI and T. PORFIRI** (representing ENEA, Rome, were unable to attend on the day but their paper was circulated to delegates)
  Energy Conscious Management of a Swimming Pool Complex

The Seminar was organised by the Eastern Region Energy Group in the U.K. which promotes energy conscious design and operation of buildings by programmes of seminars, workshops and visits for building professionals.

The seminar considered three types of building using case studies of a primary education building design, a tertiary education building design, and the design and operation of leisure pools.

The development project planned by Essex CC utilises computer aids to optimise the integration of the factors affecting the internal environment, including the relationship between daylighting/artificial lighting/orientation/glazing areas and insulation levels/mass/solar gain. The techniques being evolved promise improvement in cost effective design, both in the use of materials and in the life time operation of buildings. The problems are complex, but the monitoring of the comparison between predictions and actual performance will allow continuous refinement of methods.

Whilst school design techniques are being developed, guidelines for the design of school buildings are being drafted to assist project architects and engineers not experienced in the requirements peculiar to educational establishments. The need has arisen in the UK as the responsibility for initiating new buildings is becoming increasingly devolved to local Boards of Governors of schools.

The guidelines which embody the practical experience gained by designers over many years are energy conscious, and include a check list for the body authorising the work.

The designers of the new Campus for the university of Chelmsford were posed twin problems of a very difficult site and a fast track building programme, but responded with an innovative solution incorporating passive ventilation integrated with the glazing to give daylight enhancement and obviate the need for air conditioning.

To attract grants new sports facilities have to demonstrate that the energy aspect has been properly considered, and measures and methods to achieve this were indicated by case studies of recent buildings.

The high energy use of these buildings and how effective management in operation and maintenance could significantly reduce consumption was clearly demonstrated by presentations of monitoring work carried out.

8.6. Improving energy efficiency in educational buildings

Seminar held in Milan, 2 December 1994. Papers presented to the Seminar:

- **P. GATTERMANN**
  The Austrian Energy-Passport and its application to School Buildings
- **M. PATEL**
  Energy Savings in U.K. schools.3 Case Studies
- **R. LAZZERINI**
  The I.E.A. Working Group on Energy Efficiency in Educational Buildings - Results and proposals
- **N.A. ANGELLA**
  Energy Savings in the School Sector in Italy
- **G. DA VILLA**
  Systems oriented to energetic optimisation of intermittently used buildings
- **G. FUNARO**
  ENEA activities for Diffusion of Energy efficiency in Educational Buildings
- **A. PELA**
  Not technological obstacles to the use of Renewable Sources

This Seminar presented some conclusions of the work performed in the three years activity by the I.E.A. Working Group on Energy Efficiency in Educational Buildings, as outlined in the Final Report.

The last section of this Report represents the **Guidelines** for energy efficient management and maintenance in schools, with simple easy-to-follow rules for saving energy.

The aim of this Guide is to provide school managers and operators with advice and methods and procedures to operate their systems efficiently.

Generally, in most schools energy represents the second highest item of expenditure after staff salaries. The energy consumption may be reduced by adopting expensive measures directed to improve the efficiency of all systems operating in the school, and to increase the thermal insulation of the building fabric, but it is recognised that the influence of the users of the school is always more important.

Even the most well insulated building with all the energy efficiency measures would still end up using a lot of energy, unless the users of the building are consciously making an effort to reduce energy usage.

The intent of this Guide is therefore to help the school personnel and pupils to adopt a way of life and a mentality open to new tasks and new objectives, directed more to manage efficiently the school systems, than to seek expensive alterations or modifications.

This is the area of **Good Housekeeping**, which a school should tackle first to cut its energy cost.

The most rapid results in energy conservation come from improvement in "housekeeping" and from careful maintenance of both building and heating plant: this can give quick return for low expenditure.

In England all schools are now responsible for their own budget; this means that if they spend too much on energy they will have to make cuts in other areas, like purchase of books, or even reduce the number of teachers. As the schools are now paying for energy themselves, there is a tremendous interest among headteachers and governors in how they can save money.

The Department for Education have been encouraging schools to save energy for the last seven or eight years. The Department and the Energy Efficiency Office of the UK have undertaken a number of initiatives including demonstration projects, publications and seminars. Last year DFE ran 40 seminars for head teachers and governors.

Good housekeeping is of absolute importance in this respect. It has to be remembered that good housekeeping and saving energy does not mean cold, dark schools. Thermal comfort is striking a balance between temperature and air movement. How many times do we go into schools to see in the middle of winter that a classroom is very hot and the teacher has opened the windows in order to cool it down instead of turning down the thermostat. Do we really need all the lights on all of the time, that is not good lighting, that is just wasteful lighting.

Energy conservation is not just a technical fix, it is a mixture of low tech people power, and the state of the art technology. In all this energy saving effort it is extremely important to involve the children. Most children today are very aware of green issues, energy conservation gives them an opportunity to try things out themselves in the school.

Today in England energy is taught as a part of the national curriculum subjects, in science, technology, geography and history, and by carrying out energy efficiency in schools the pupils can see the benefits of their own contribution. In many schools teachers are appointing pupils as energy monitors to switch off lights, to close doors and windows etc.

Success will come from a carefully thought out balanced action plan that brings together the widest range of measures. In the best schemes the staff, the pupils, the headteacher and the caretaker accept personal responsibility and work with each other to save energy, it should be a team effort with positive leadership from the headteacher. Staff and the pupils must know what they are trying to achieve and be given real credit for commitment. Energy conservation should be for life. If as young children, pupils develop energy conserving habits in their schools then when they grow into adults the future generations will come to regard energy as a scarce and a valuable resource which should be used properly.

A different situation exists in Italy, in the school sector, but the importance of responsibility and of autonomy of management is fully recognised.

A special Decree concerning new administration rules for schools is now being considered in Parliament, but its final approval will certainly take some time.

Each school will become self-governing with possibilities to directly manage many items of the budget, and draw up contracts with third parties.

The aim is to encourage adoption of energy conservation measures, to reduce the energy bill, and use again in the same school the money saved in this way.

In view of the poor energy balance of existing Austrian schools, and with the purpose of including energy consumption in the design considerations for new school building, an energy coefficient is supposed to be introduced in Austria in 1995.

Expressed in megajoules, this energy coefficient represents the specific energy use of a building over one year. This energy use results from the interaction of various factors, such as the physical properties of a building, the installations, local climate, kind of operation, user behaviour, as well as the massing and storage behaviour of the building and its receptivity for passive solar energy. Also with regard to the increasing CO_2 emission into the earth's atmosphere, energy conserving construction will be gaining in importance.

The purpose of this method is to determine the heating requirement of a building with due consideration of passive solar energy use and standardised user influences so as:

1. to assist in the design stage when deciding on the kind of energy conservation measures to be adopted in each individual case;
2. to be able to compare different buildings as to their expected heating requirements;
3. to define the characteristic heating requirement for a specific building using a uniform method, and to compare it with a nationally specified standard value (energy coefficient).

The computation method is based on the thermal balance of a building which is usually determined every month with the aid of computers to save time. The heating requirement for a specific heating period is defined by adding up the individual monthly data.

The following energy influence quantities determine the heating heat requirement:

1. Heat transmission losses;
2. ventilation heat losses;
3. solar heat gains;

4. internal heat sources due to the operation of electric appliances, artificial lighting, body temperature of people and animals.

Other factors of minor importance such as sewage or room air humidity, are neglected.

Influence quantities likely to have a major impact on the heating energy requirement, such as the user behaviour of occupants (ventilation habits, use of electric appliances, sunshading and room temperatures), are determined by standardised parameters (standard user behaviour) for requirement computation.

This calculating method is thus a highly suitable design tool to optimise the energy efficiency of buildings and an adequate calculating method to produce evidence that any nationally prescribed standard value (energy coefficient) is being met.

The use of the energy passport makes it possible:

1. to demand architects calculated proof of the heating requirement to be expected from a building just being designed;
2. to determine the characteristic heating requirement of existing buildings based on a uniform calculation method to be able to compare it with a nationally prescribed energy coefficient and optimise it accordingly.

Reduced energy consumption will result in reduced CO_2 emission; less polluted air is tantamount to actively applied environmental protection. Hence the use of the energy passport can be seen as a substantial contribution to preserving and improving our environment in future.

The results of a survey conducted on a large number of schools in Italy are reported, thus permitting evaluation of the average energy consumption in the school sector, which is of the order of 650,000 TOE/year.

Considering the possibility to apply energy conservation measures on a large scale, a 20% reduction in energy consumption is considered feasible, with a saving of about 130,000 TOE/year.

The majority of programmed measures refer to actions directed to improve the efficiency of the mechanical and electric systems such as:

- replacement of normal bulbs with high efficiency lights;
- replacement of boilers;
- insulation of pipework;
- installation of thermostatic valves;
- zoning of the heating system;
- use of alternative fuel;
- application of heat recovery units.

The results of the operation of the heating system in a school building, equipped with a special BEMS, are reported.

This is a typical two storey school building of the 1970's, with large glazing surfaces, about 2,000 m^2 floor area, and a 500 m^2 gymnasium.

Each radiator has been equipped with an automatic modulating valve, with a temperature sensor in each room.

All valves are connected to a central unit which controls the time of operation, the temperature ramp and variation, ambient temperature separately for each room, according to a pre-set programme.

The reported results have been the following:

- more comfortable temperatures in all parts of the building;
- uniform temperature in all rooms;
- a reduction in energy use of about 20%;
- possibility to use only some spaces of the building, heating them at an optimum level of ambient temperature, while other rooms not in use are kept at lower temperature, or even with the heating system shut-down.
- the cost of this system is reported to be in the order of 1,000,000 Liras for each controlled point.

According to a recent survey, the school building stock in Italy is split as follows: 3% of the buildings have been constructed before 1,800 A.D.; 4% between 1,800 and 1,900; 18% between 1,900 and 1,946; 75% after 1,946.

53% of the school buildings are located in urban zones, 39% in suburban zones, and 8% in mountain zones or in the islands.

PART THREE - ENERGY AND ENVIRONMENT

9. SCHOOL AND ENVIRONMENT

Schools present unique problems in terms of internal environment. They generally have short periods of occupancy, weekdays only with long holiday periods; 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.

Therefore, the necessity of a more rational management of the energy involved has been generally recognised.

It must also be pointed out that energy conservation measures taken 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.

The nature of the local environment is an important factor in the atmosphere of a school. Air quality, the landscape, the built environment and social conditions all contribute. Protection against noise and dust is sometimes still necessary in towns, while in rural areas with good environmental conditions, such protection may not be necessary. A school should be designed to take account of the local climate, local construction materials and local types of building, and thereby contribute to regional culture.

A 70 m^2 classroom contains about 130 g of CO_2 naturally in the air.

The energy used to provide heating, lighting and power to that classroom for one year would produce about 4,000 kg of CO_2.

A sustained programme of investment in energy conservation will not only pay worthwhile financial dividends in future years, but also address the growing concern over the environmental consequences of burning more fossil fuels, and the depletion of finite resources.

The consumption of energy is a major source of environmental pollution. The principal greenhouse gas, carbon dioxide, is produced when fossil fuels are burnt. Sulphur dioxide, the main cause of acid rain, is emitted when coal is burnt in power stations.

The emergency of the threat to the environment from the greenhouse gases has reinforced the financial argument to reduce energy consumption.

Cutting energy consumption is increasingly seen by a number of Authorities as an integral part of a wider environmental audit; saving energy helps limit emissions of greenhouse gases. So it makes global environment sense to take action now.

The need to avoid energy waste is not just a temporary green issue that will fade with time. A continuing effort is required to achieve higher environmental standards.

The major way that Authorities can contribute to a reduction in greenhouses gases and a cleaner environment is to follow a policy of improving the energy performance of their building stock.

9.1. CO_2 emission

Data for CO_2 emissions are often considered as a general indicator of the situation existing in one country, concerning pollution due to fossil fuel combustion.

Recorded data for CO_2 emissions in each country are here reported to give an idea of the pollution situation.

As a comparison datum, the figures of CO_2 emission per capita, as an average for the total of 12 E.E.C. countries, recorded in the years from 1985 to 1991 is reported in Table 5.

9.1.1. Austria

- total CO_2 emission 60.0 Mt
- CO_2 emission per capita 7.67 t

Table 5 - CO_2 emission per capita

	1985	1986	1987	1988	1989	1990	1991
[T/capita]	8.2	8.2	8.3	8.3	8.4	8.4	8.7

9.1.2. Greece

- total CO_2 emission 72.8 Mt
- CO_2 emission per capita 7.2 t

9.1.3. Italy

- total CO_2 emission 400.9 Mt
- CO_2 emission per capita 6.9 t

9.1.4. Spain

- total CO_2 emission 223 Mt
- CO_2 emission per capita 5.7 t

9.1.5. U.K.

- total CO_2 emission 588 Mt
- CO_2 emission per capita 10.2 t

9.2. Measures for environment protection

Specific regulations and standards have been issued in several countries for the protection of the internal and external environment in the school sector.

Examples of measures taken in the five participating countries, are here reported.

According to the European Community Council Directive Relating to Construction Products (89/106/EEC), *Member states are responsible for ensuring that building and civil engineering works on their territory are designed and executed in a way that does not endanger the safety of persons, domestic animals and property, while respecting other essential requirements in the interests of general well-being.*

The Directive specifies the main requirements as regards hygiene, health and the environment in quite general terms:

Construction work must be designed and implemented in such a way that it will not be a threat to the hygiene and the health of the occupants or neighbours, in particular as a result of any of the following:

- *the emission of toxic gas;*
- *the presence of dangerous particles or gases in the air;*
- *the emission of dangerous radiation;*
- *pollution or poisoning of the soil;*
- *faulty elimination of waste water, smoke, solid or liquid wastes;*
- *the presence of damp in part of the works or on surfaces within the works.*

If these rules are strictly interpreted, many building materials that are now commonplace will have their use severely restricted.

9.2.1. Austria

In Austria, since 1993, building waste is separated, collected, and if possible recycled. Contractors are required to sort waste material into the following categories:

- excavated material;
- asphalt rubble;
- plastics;
- metals;
- concrete rubble;
- wood (unpainted);
- mineral waste such as bricks, mortar, plaster work.

Excavated material can be re-used elsewhere, and concrete is re-used especially in road building, as is asphalt rubble. Bricks present a problem since they are not frostprooof when broken; plaster is sensitive to water and has to be treated carefully because of the chemical components. Storage of material until it can be re-used also requires care because of potential groundwater pollution. Some items, such as wooden window-frames, cannot be re-used. It is estimated that the cost of separating building waste amounts to some 3 per cent of total building costs.

9.2.2. Italy

No information given.

9.2.3. Spain

No information given.

9.2.4. U.K.

In the United Kingdom, guidance has been available since 1981 on energy savings by means of natural lighting, natural ventilation, the use of solar energy and a good heating-control system. England was the first country (in 1961) to build a school heated entirely with solar energy. In the past few years these ideas have been increasingly applied and a number of schools are now using solar energy.

Natural lighting is important since electricity accounts for over 40 per cent of a schools' energy consumption, and electricity consumption has risen greatly in the United Kingdom in the past few years. The aim with natural lighting is to achieve a minimum daylight factor of 4 to 5 per cent at working-surface levels.

In the United Kingdom, artificial ventilation may account for up to 50 per cent of energy consumption in schools. Accordingly, greater importance is now being attached to natural ventilation in which air is changed by means of high level roof lights or ventilation shafts.

These energy-saving principles have to be applied, however, not only to the few new schools being built but also to the approximately 25,000 existing schools. These schools must be renovated from time to time and this provides an opportunity for action to be taken to save energy, depending on whether walls, roofs, windows or heating systems are being renovated. In the case of schools built in the 1960s and 1970s the window areas, which amount to up to 70 per cent of the external wall area, are often reduced to 35 per cent, with upper windows being kept for classroom lighting. These energy-saving measures also contribute to a reduction in carbon dioxide emissions and to the maintenance of a healthy environment.

PART FOUR - ENERGY AND CURRICULA

10. GENERAL CONSIDERATIONS

The aim is 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 between professional energy management in schools and the curriculum requirements for energy education must be pointed out.

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

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 possible methods as there are schools: each needs to be individually tailored.

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.

Publicity, 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: "anyone".

Strategies to achieve this may be purely school based or they might be externally supported. In some cases the opportunity of the organisation of many schools may be considered. If shared with other schools in a local consortium the shared cost could be good value for money.

10.1. The role of pupils

Pupils are the reason why schools exist. They are an important key to successful energy management. Without their understanding and active involvement, improvements in equipment and controls will be of limited benefit in reducing energy consumption.

The School Energy Manager should identify the broad energy education requirements of the whole curriculum. This could involve looking at both the national curriculum and external examination syllabi, together with the school's own schemes of work. Consultation with teachers may be necessary to clarify the meaning of these documents, especially where subject-specific jargon is being used.

The School Energy Manager is then in a position to suggest to teachers how the school building, its heating and lighting systems, and other equipment can be used as an additional, readily-available, free learning resource. Stress should be laid on the educational benefits of demonstrating how the concepts met in the classroom laboratory and workshop are applied to real problems in a situation with which pupils are already familiar. It is an excellent way of encouraging pupils (and adults) to confront any misconceptions about what they thought they already knew.

Pupils should be encouraged to:

- study the way in which energy in used (and misused) in their school;
- investigate the factors (physical, technical and behavioural) that affect energy use;
- suggest ways in which energy efficiency could be improved;
- carry out experiments to determine the effectiveness of their proposals;
- report to the school's management on their research;
- assist the management in implementing those recommendations that are adopted;
- evaluate the effectiveness of the measures taken;
- suggest modifications or additional improvements;
- update fellow pupils, teachers, staff and out-of hours users on progress;
- use their understanding to benefit the energy-efficiency of their own homes;
- spread their understanding to the wider community.

10.2. The role of Energy Managers

School Energy Managers can act as a link between members of the school and the energy professionals. Most important amongst the latter are the qualified engineers, technicians and educational advisers which normally assist the school. However, it could also include advisers from utility and other companies, together with personnel from government departments and agencies, energy education charities and energy advice centres.

The aims of these links should be to provide:

- all members of the school community with a basic knowledge of the existing systems, their functions and limitations, so that they can operate the school in an energy-efficient manner;
- consumption and cost data which can be processed by pupils, especially in mathematics and economics lessons, to determine for themselves whether reductions have been made in energy use;
- examples of the component parts of the system for examination and investigation, especially as part of science and technology lessons;
- information on the availability of other energy education resources;
- the energy professionals with information about the apparent performance of the school's systems, so that they can deal with the problems perceived by the users of the buildings, and encourage their co-operation in managing energy;
- all members of the school with a sufficient understanding of energy efficiency strategies and practices that they can successfully apply them in their homes, leading to both improvements in comfort and reductions in cost.

School Energy managers should also encourage:

- energy professionals to contribute to the teaching/learning process;
- all members of the school community to feel that they: have ownership of the school's energy policy, benefit from its implementation, have a constructive role to play in discussing the lessons to be learnt from its failures and successes;
- all school members to discuss the environmental and financial implications of energy use and misuse, and the re-allocation of financial savings;
- pupil-centred co-ordination of energy education across all curriculum subjects;
- the consideration of the energy implications of management decisions;
- the establishment of a Schools Holistic Approach to the Management of Energy.

10.3. 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 today's generation who tomorrow will take decisions.

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

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

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

10.4. Some Key Developments in Energy Education in the UK

Some projects are limited to energy, but many are part of wider environmental activities.

1. School Turnkey Energy Programme - This is a national series of seminars to raise the awareness of head teachers and governors of the opportunities to reduce expenditure on energy, the management issues involved, and the technical support that is available. It is managed by the Building Research Energy Conservation Support Unit, Watford, on behalf of the Department of the Environment's Energy Efficiency Office.
2. The Green Brigade - A national scheme to encourage young people to become involved in environmental action. A panel of young people advised the Government on which projects should be supported.
3. The Esso Young Energy Savers - A scheme for introducing classes of children aged 5 to 11 years to energy and its wise management within their school and homes. The teachers have the support of specially trained officers from their local Groundwork Trust (a group of charities which empower people to improve their own environment). Esso YES is being developed by the Groundwork Foundation, with funds from Esso plc and the Energy Efficiency Office.
4. The E-Team - A scheme initially developed by a teacher in Newark, Nottinghamshire, to encourage the pupils at his school to see the environmental impact of their school, and implement ways of reducing it. Support has come from Newark and Sherwood District Council and the North Nottinghamshire Training and Enterprise Council, together with local utility and industrial companies.
5. Many local authorities have their own schemes to encourage energy efficiency in schools. Their scope, methodology and success vary widely. The practice of schools managing their own energy budgets is too new within England and Wales for a consistent approach to have been developed, even if this were desirable.
6. The principal government departments and agencies have joined with the leading educational, professional and charity organisations to form the Energy Education Forum. This acts as a conduit for the flow of information, ideas and advice between the key supporters of energy education.
7. Large-scale school and public education projects involving Local Energy Advice Centres, broadcasters, public utilities and educational charities etc. are being planned.

PART FIVE - ENERGY EFFICIENT SCHOOLS

11. TRENDS IN THE CONSTRUCTION OF NEW SCHOOLS

During the last 20 years extensive experimental and research work has been done in all countries with the object to improve the performance of school buildings and systems, increase efficiency and consequently reduce energy consumption, and minimise the impact on the internal and external environment.

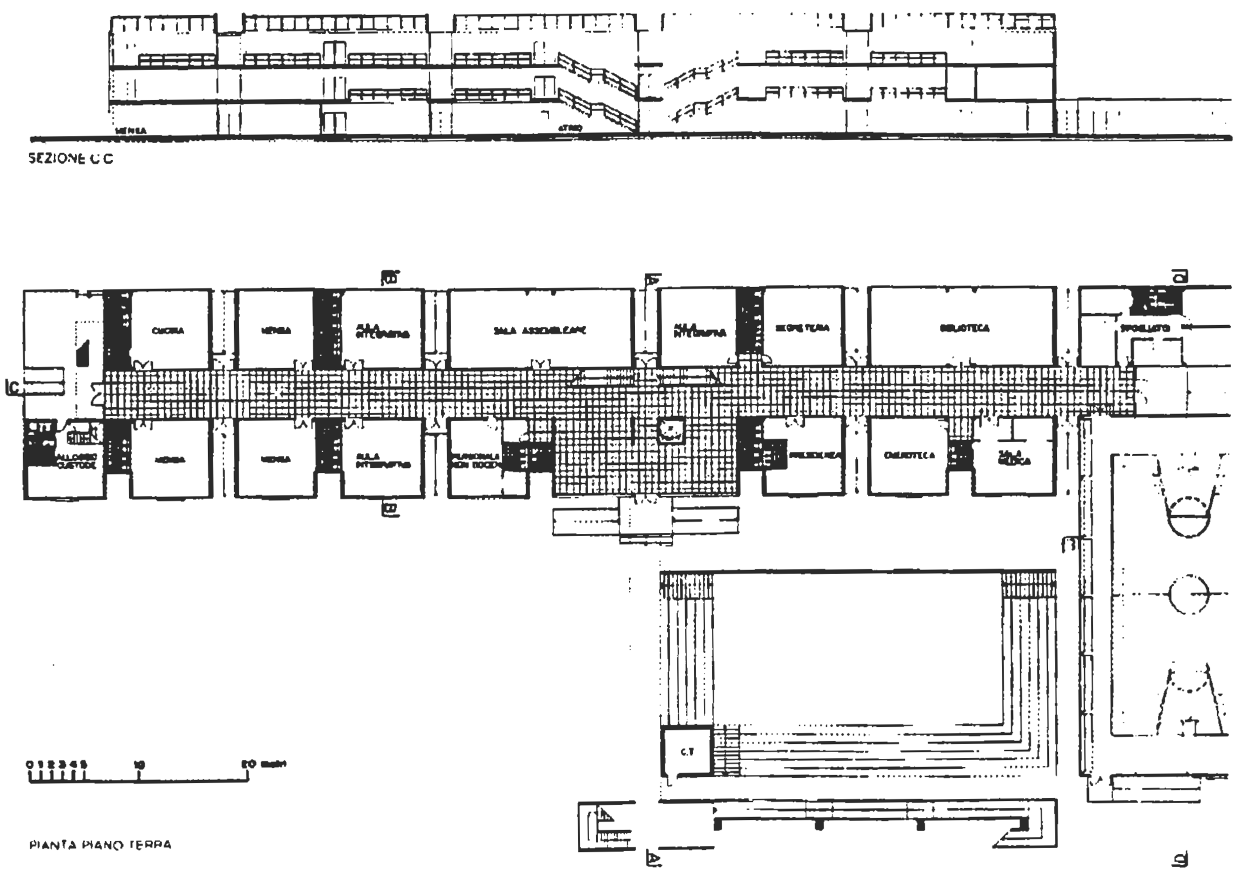
The thermal and energetic behaviour of buildings under realistic conditions is now better known and represented by many computer simulation programs that have been compared and validated within International research projects. At the same time the field of the **Healthy Building** and that of the **Bioclimatic Building** have been analysed.

The development of research and the demonstration project have led to the concept of **Energy Efficient Schools** which incorporate also the other two mentioned aspects.

The main energy design features are considered to be the following:

- optimal orientation of the building;
- optimal insulation of walls, floors, roofs, windows, etc., to reduce the overall value of U ($W/m^3 \cdot K$);
- rational use of passive solar systems;
- application of active and mechanical solar systems;
- emphasis of natural ventilation to all teaching areas, and limited use of mechanical ventilation in other areas;
- use of high efficiency boilers for the heating systems;
- zoning of the heating system;
- rational use of B.E.M.S. and automatic control devices;
- good natural daylighting;
- low-wattage fluorescent and compact fluorescent lighting;
- consideration of the possibility to adopt heat recovery devices.

Figure 12



11.1. Austria

No information given.

11.2. Greece

No information given.

11.3. Italy

11.3.1. Technical School of MONTEFIASCONE (near Rome, Italy)

The Technical School of MONTEFIASCONE (see figures at pages 57, 58 and 59) presents some interesting architectural and technical solutions, which try to give a reasonable answer to the energy problem in terms of cost, technology and architectural quality, by means of a system in which the solar component has a significant impact.

Built in 1980, the school has a main three storey building, measuring 93.30 by 19.50 metres. 10.0 metres high.

It is formed of five teaching blocks, each one measuring 17.10 by 19.50 metres, 10,0 metres high.

The five blocks are crossed by the central distribution corridor which divides the building longitudinally.

At ground floor there are: gymnasium, offices, library, doctor's room, conference room, some special class-rooms, kitchen and students' dining room: all classrooms are placed at first and second floor.

Passive and active solar concepts have been applied: the south facade is fully covered with wide windows screened by sunshades, and with air solar collectors.

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

The boundary elements of the building have been designed with the intent to minimise heat losses, with the following U values:

- external walls facing South: 0.45 $W/m^2 \cdot K$
- external walls facing North: 0.40 $W/m^2 \cdot K$
- external walls facing East, West: 0.7 $W/m^2 \cdot K$
- floor: 0.7 $W/m^2 \cdot K$
- roof: 0.72 $W/m^2 \cdot K$
- glazing: 3.2 $W/m^2 \cdot K$

<u>Heating system</u>

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

- minimum winter external temperature: -3 °C
- internal temperature: 20 °C
- classrooms ventilation: air changes per hour: 5
- services ventilation: air changes per hour: 2.5

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

For the ventilation air, a separate system is installed; external supply air is first forced to pass through the solar collectors, and after pre-heating it

Figure 13

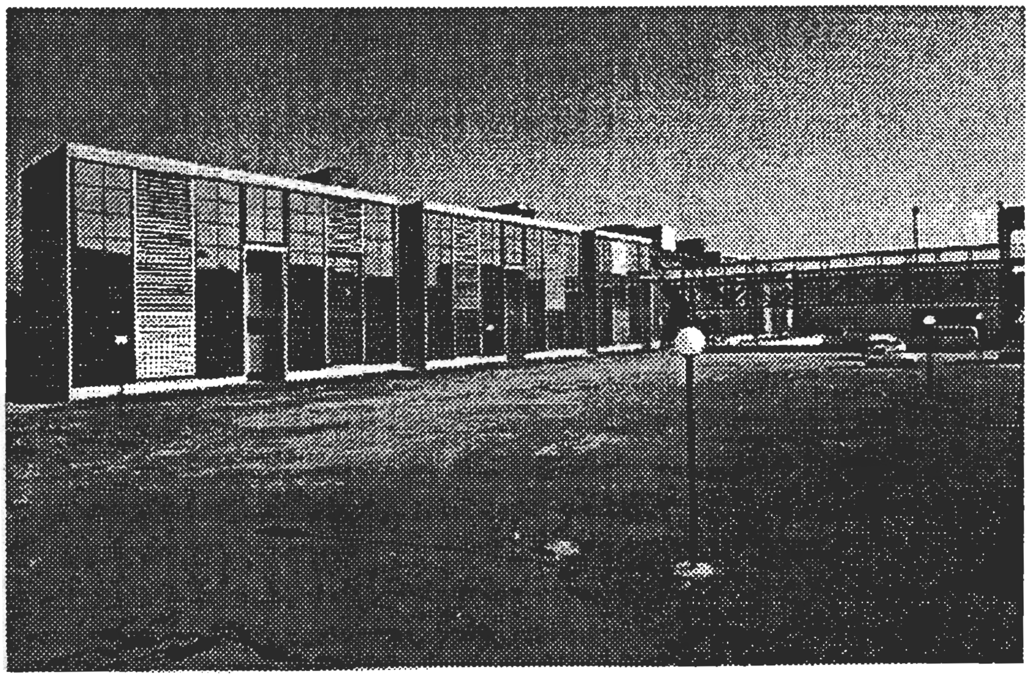
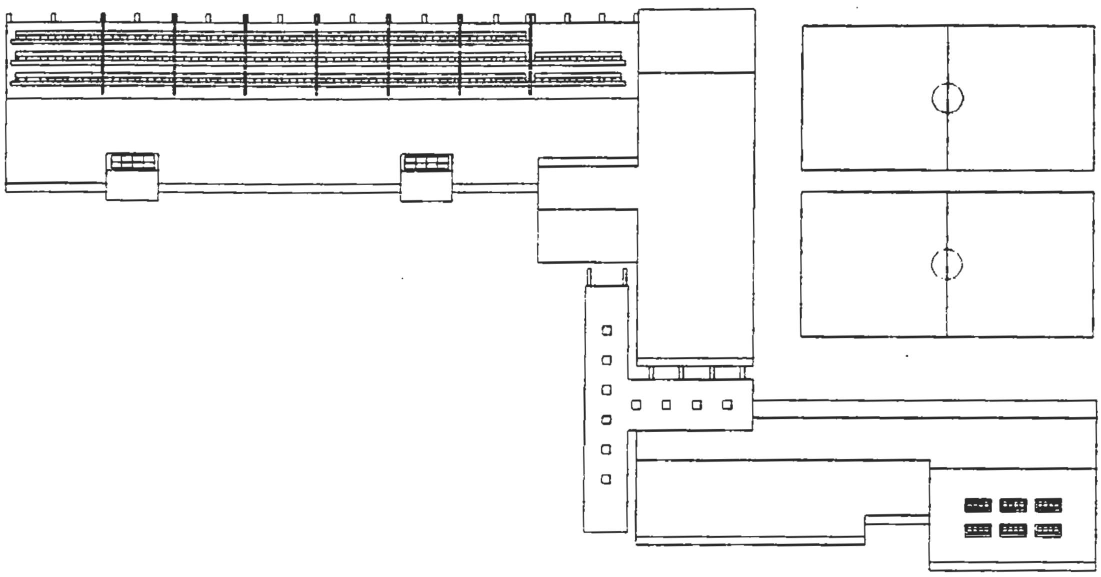


Figure 14



enters four conventional air handling units, connected to the hot water system, where temperature and humidity of the air are adjusted according to the indication of the central control system.

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, maintains the room set conditions, e.g. 20 °C.

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.

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

Operation of all sections of the heating plant is automatically controlled and managed by a central system: every room of the school may be checked individually, altering the ambient temperature when required, with the possibility to shut-down rooms when non occupied, thus preventing unnecessary waste of energy.

The control system also provides monitoring of plant conditions and checking of efficiency in real time.

11.4. Spain

11.4.1. Bioclimatic centre in Guadalayara

This is a 24-unit school with two workshops and a gymnasium for the city of Guadalayara. The construction was adapted to the location with the application of passive techniques in order to reduce energy consumption both for heating and lighting.

__Construction__

The school is made with three building units; a three storey classroom building, a two storey building for administration and laboratories, and a third one with workshops and gymnasium.

They are all linked in a perpendicular direction although the building containing the workshops and gymnasium is separated to form an open space for the location of the sports area.

With respect to orientation, layout is as follows. The building containing the classrooms and seminars faces south-east with the classrooms facing in this direction and the seminars and toilets in the opposite direction. The building containing the administrative offices and laboratories, and ending in the multi-purpose room, face south-west and north-east. The building containing the workshops and gymnasium face the south-east (like the classrooms).

The L-shaped layout of the classroom building together with the administrative building on the lower platform of the plot was determined for topographical reasons (to avoid serious differences in level), because of the level of sunlight in the classrooms and in order to obtain more uniform foundations.

The classroom and seminar building is rectangular in shape and houses 24 classrooms and 9 seminars. It has two staircases, two groups of toilets on each floor and one lift.

The classroom windows have protection from the sun in the form of fixed, horizontal, reinforced concrete projections. The stairwells end in vertical skylights which not only throw light on the stairs but also allow heat to escape through openings in hot weather.

The administrative and laboratory building is rectangular in shape and has two floors, with two sets of stairs and two groups of toilets at each end. The administrative and principal's offices, as well as the cafeteria and heating equipment room are located on the ground floor. The four laboratories and the audio-visual room are on the first floor.

The multi-purpose room is double height with skylights. It is located next to the vestibule and links the classroom building with the administrative building. The workshop and gymnasium building is connected to the administrative building by a porch. This building has skylights to receive light and solar energy.

Building characteristics

The construction is conventional with a reinforced concrete structure on piles. The slabs are unidirectional with reinforced concrete joists and ceramic blocks. The outside walls consist of 15 cm of unfaced brick with mortar on the inside, 4 cm of fibreglass sheathing and a cavity brick wall which is plastered and rendered. The roof is of inverted Roofmate type with a gravel finish.

The windows have coated aluminium frames with double glazing.

Internal walls are thick partition walls, plastered and painted with acrylic paint, and in the passages the brickwork is unfaced. Floors are of artificial stone polished on side.

The heat transfer factors are the following:

- walls: 0.7 $W/m^2 \cdot K$
- roof: 0.71 $W/m^2 \cdot K$
- double glazing: 3.95 $W/m^2 \cdot K$

Lighting

According to standards for schools presently effective in Spain, the lighting level in the classrooms should be not less than 300 lux. In the design of this school a minimum level of 500 lux has been considered, with a uniformity of 0.8.

Daylighting is important not only for energy saving but also for a good internal environment.

The classrooms have the following dimensions:

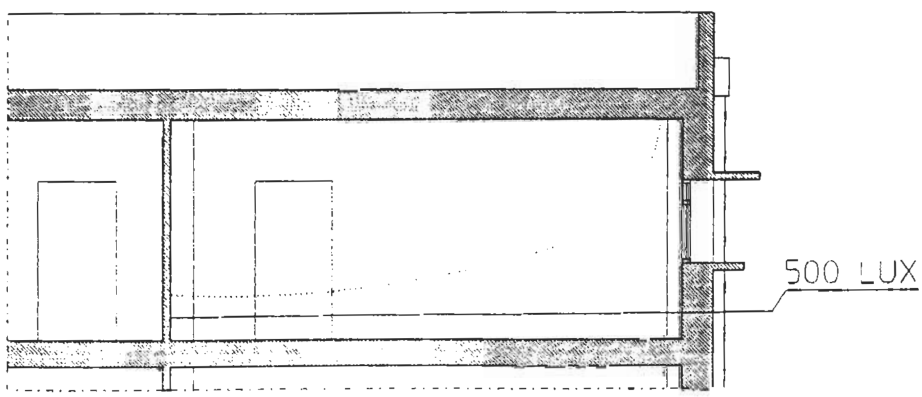
- floor area: 8.80 x 6.40 — 56.32 m^2
- height: — 2.80 m
- volume: 8.80 x 6.40 x 2.80 — 157.7 m^3
- total internal surface: — 187 m^2
- area of the windows: — 10.53 m^2

The pattern of illuminance due to daylighting in the classroom with south-east orientation is shown in Figure 15.

According to calculations and practical results, artificial lighting is required only in January and February.

The total energy saving in this school has been

Figure 15 - Section of south east facing classroom



calculated at 27%, which amounts to approximately 158,000 kWh per year.

11.5. U.K.

11.5.1. Swanlea Secondary School

Location

Brady Street, Whitechapel, London.

The school is in the east end of London.

It is on the corner of two streets and is bounded on the north by a burial ground with some fine trees and on the west by an underground railway.

Design

In order to provide good communication between subject areas the school is designed around a main street with circulation by means of high level walkways, bridge links and a disabled access lift. By careful fire-engineering the stairs at each end of the mall have not been enclosed in fire compartments which eases the access between levels.

Form

The teaching spaces are on three storeys on the north side of the mall and two storeys on the south. The south facing slope of the roof over the mall takes up the difference in levels and also maximises solar gains. The building is constructed on a module equal to the classroom width of 8.1 metres. This is expressed externally by the classroom setbacks and the repeating crest shaped slopes of the classroom roofs.

Construction

Bored cast in-situ piled foundations support a ventilated suspended ground floor slab. The walls are of loadbearing blockwork clad with bricks or cladding panels with insulated cavities. The street elevations are mainly in yellow London stock bricks, similar to existing local buildings. Internal walls are largely of plastered loadbearing blockwork with extensive glazing onto the mall.

Blockwork partitions provide the robustness, fire resistance and acoustic separation needed and are an economical form of construction. Precast gutters provide fire stability to the compartment walls.

Upper floors were formed with precast shuttering with integral void formers to provide service routes and reduce weight.

The curved roofs to the classrooms are built up from profiled aluminium sheet with standing seams carried on curved steel T-sections.

Passive features

The mall is glazed with special glass panels. These are hermetically sealed and double glazed. They incorporate purpose designed **Okasolar** reflective glass prismatic strips set at predetermined angles (Figure 16). The angles of the prisms are adjusted depending on the location of the glass panel on the roof slope. This is because the slope of the roof gets steeper towards the bottom. The angle is chosen to reflect the majority of the sunshine in summer and to transmit the majority in winter. The angle depends on the altitude of the sun in summer and the angle that the glazing makes with the horizontal.

The glass prisms are reflective and are a form of fixed shading device. The glass is largely self-cleaning as the minimum slope is 15 degrees.

The mall is unheated except for passive-solar

Figure 16

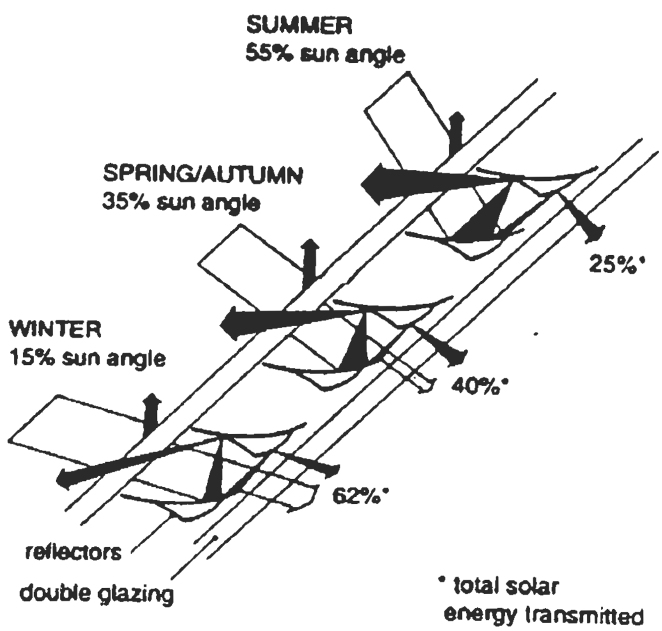
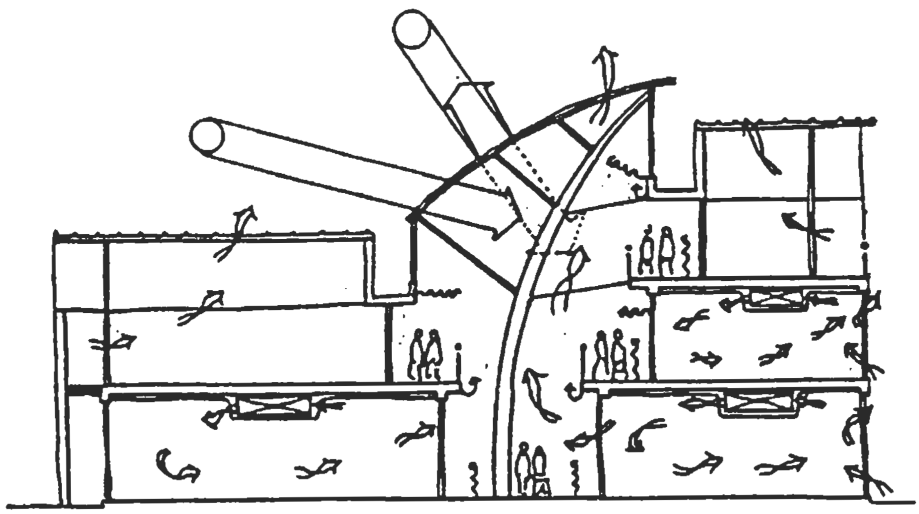


Figure 17



gains and gains from the adjoining classrooms. Significantly, there have been no complaints that the mall is too hot or too cold. It therefore provides a useful thermal buffer space. The end walls are fully glazed as is the opening onto the south exhibition courtyard. In the heating season, when the temperature of the air in the mall reaches 20 °C it is used as a preheated supply for the mechanical ventilation system serving the classrooms.

In summer, overheating of the mall is prevented by thermostatic opening of the fire ventilators located in the top section of the sloping roof.

Heating and ventilation

Both the cavity-walls and the roof are well insulated with U-values around 0.3 $W/m^2 °C$, much lower than required by the Building Regulations. The larger classrooms, laboratories and technology spaces are provided with mechanical ventilation. A scheme of natural ventilation using the stack effect generated in the mall was considered but was found to conflict with the necessary fire and acoustic separation. However, heat reclaim using plate heat exchangers (for low maintenance)and the use of solar preheated air from the central mall make the ventilation system energy efficient.

Out of hours use of part of the building is easy with heating-on times of four separate heating zones controlled from a central computer. Also a separate boiler house serves the catering and sports area. The main boiler house serves the rest of the school.

The heating system has weather compensation, optimum start and radiators are fitted with thermostatic valves. Hot water is provided by local hot water generators except for the kitchen and shower rooms which are served from their own boiler plant.

Lighting

The maximum amount of daylight is admitted to all areas. Classrooms are lit from two sides; from the main view windows and from the clerestory glazing under the raised edges of the classroom roofs.

Light is also borrowed from the central mall.

High frequency fluorescent lighting is used in most areas. In the classrooms a two stage switching arrangement controls each of 2 sets of bulbs in each luminaire so that the lighting can be adjusted to suit the level of daylight available. A central time control enables all classroom lights to be switched off at break or lunch time. This has proved cost effective in other schools.

Energy

The building has predicted primary energy consumption figures which are much lower than the Department for Education target values. The energy efficiency is due in large part to the simple heating and lighting controls aided by the unheated passive solar mall.

11.5.2. John Cabot City Technology College

<u>Location</u>

Woodside Road, Kingswood, Bristol.

The site falls away both to the north and to the west and the area which could be developed was severely restricted. There is a good view in the north-west direction towards the new grass amphitheatre and existing orchard, which are the focus of the new crescent block.

<u>Design</u>

This is an innovative design for minimum environmental impact, using simple, easily comprehensible environmental controls including a Building Management System, and natural ventilation and daylighting of deep-plan spaces where possible.

Teaching spaces are of high quality and responsive to the external climate.

<u>Form</u>

The crescent-shaped spine runs roughly north-east to southwest and is the primary circulation route through which the main parts of the building are approached. At the north end of the street is the administration office, entrance atrium, main hall and dining room. At the south end of the street is the sports hall placed at the lowest level of the site. Running south east off the street are three 2 storey, deep-plan classroom blocks. The layout of the building is intended to provide specific principle circulation routes and side streets and public spaces that provide many opportunities for social interaction.

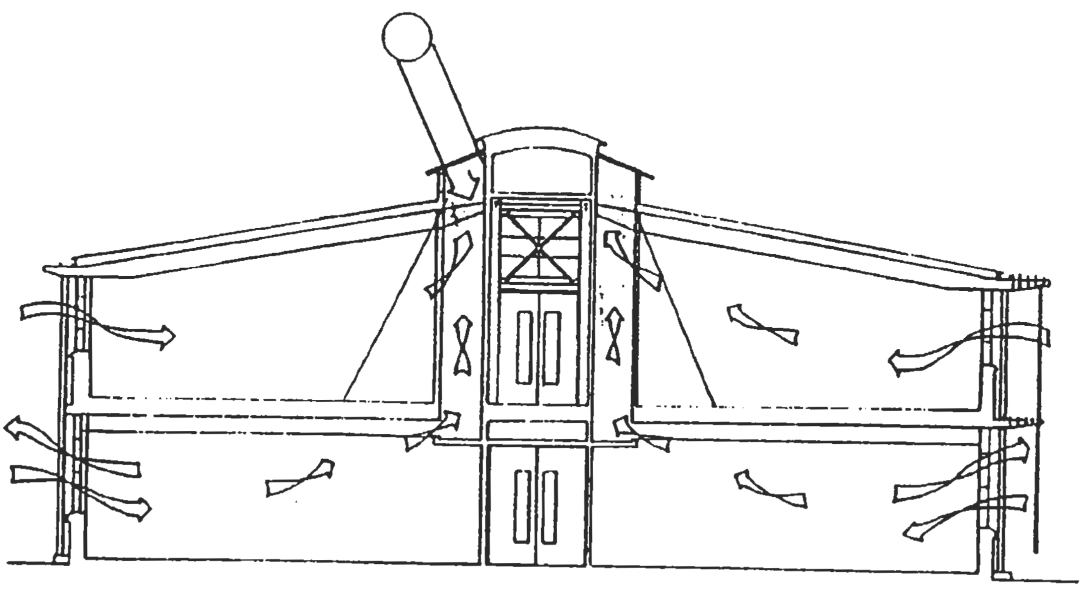
The circulation is designed to reinforce departmental identities.

<u>Construction</u>

The building is steel framed with brick walls and aluminium framed windows and curtain walling infill and cladding. The exposed steel columns on both the wings and the crescent, provide fixings for the solar shading, structural support for the roof and act as rainwater down-pipes. The thermally broken aluminium windows are double-glazed and powder-coated.

The majority of the roofing is low profile metal decking but terne-coated stainless steel is used on the curved part of the crescent. Floors are cast-in-situ concrete slabs on reinforced strip footings under column lines. Wall finishes are either plastered or fair-faced brickwork. There is a suspended ceiling on the ground floor, to allow for service runs.

Figure 18



The acoustic lining on the upper floor follows the roof line.

The building "U" values are:

- Walls: $0.35\ W/m^2 \cdot K$
- Roofs: $0.30\ W/m^2 \cdot K$
- Ground slab: $0.45\ W/m^2 \cdot K$

Passive features

The exposed floor mass in the street absorbs heat from the winter Sun.

Extensive motorised translucent solar blinds allow 65% of the external wall to be glazed to minimise energy use by using daylight, whilst preventing summer overheating. The classroom wings are designed to maximise the use of daylight and natural ventilation.

Heating and ventilation

Natural ventilation inlets and outlets have been designed for all spaces. Some of the air inlets are combined with warm air heaters and the outlets are controlled automatically.

The classroom wings have ventilation shafts down to the ground floor. These provide cross-ventilation to the deep plan.

Heating is extensively zoned and controlled by a Building Energy Management System (BEMS) with a central computer and printer. One of the three gas-fired boilers is condensing and supplies a low temperature underfloor heating system in the entrance atrium, main hall, and drama space.

Warm air heating systems provide a fast response in the sports hall, sports changing room, kitchen and dining room.

Classroom blocks and circulation areas have radiators.

Direct gas-fired storage water heaters are provided in the sports changing rooms, and kitchen and point-of-use electric water heaters are used in toilets and teaching areas.

Cooling is only provided to the business studies room where there are a lot of computers.

Lighting

Recessed fluorescent fittings on the ground floor and surface mounted fittings on the first floor are fitted with high-frequency control gear and louvres to provide the necessary quality of light for frequent use of visual-display terminals.

There is external access and security lighting and floodlighting of outdoor sports areas.

Energy

The design annual energy consumption in primary energy units is 173 kWh/m^2.

This should be compared with the 1981 Department for Education Design Note 17 required maximum of 240 kWh/m^2.

PART SIX - ENERGY CONSERVATION MEASURES

12. GENERAL

Keeping in mind the final objective to reduce the energy consumption, we may consider 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 three 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 them more efficient;
3. improving management and maintenance procedures.

12.1. Reducing heat losses

Most of the heat generated in a school is lost through:

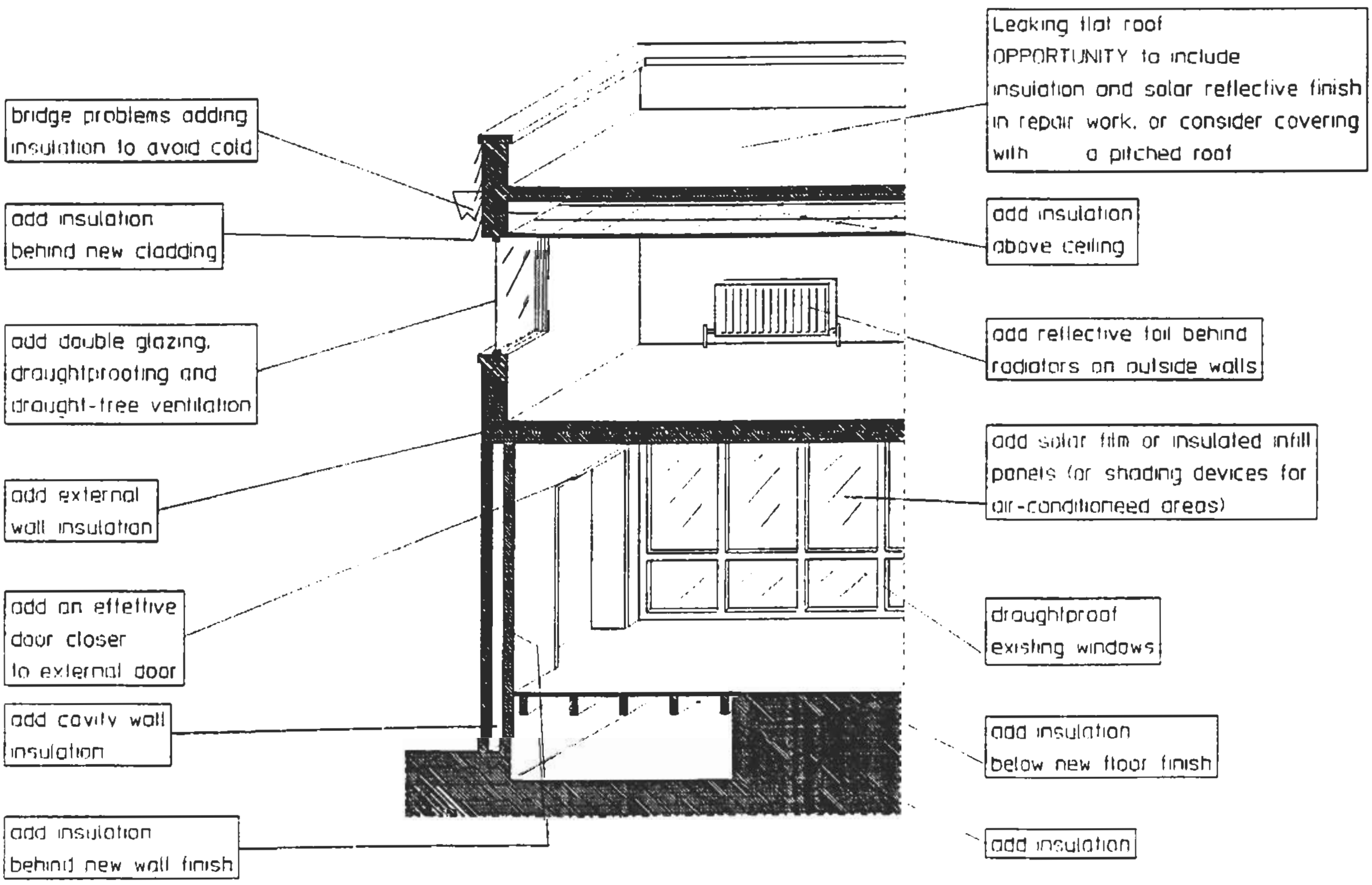
- the building fabric (walls, windows, roofs and floors)
- air infiltration, and
- ventilation

Insulation and double glazing reduce the rate of heat loss, while good temperature control can maintain comfort levels without overheating.

12.1.1. The building fabric

Heat loss through the building fabric can be reduced by a wide range of measures, which include adding thermal insulation, double glazing and draught stripping. The purpose of providing insu-

Figure 19



lation in the roof and walls of a school is to retain during the heating season as much as possible of the internal heat from whatever source, including the heating system, electric lighting, other plant, occupancy and school activities and solar gain. A high level of thermal insulation has a further benefit in that it helps to make the internal surfaces of the building warmer and thus reduces heat loss from the body by radiation and, in the case of the floor, by direct contact. The risk of condensation in also reduced, provided that the vapour barrier is correctly positioned within the construction. However, applying many of these measures to a whole school can be expensive. Generally, therefore, fabric improvements tend to be less cost-effective than improving the heating system and its controls.

Nevertheless, there are a number of fabric improvements that are worthwhile and these are described in the following sections, and reported in Figure 19.

Before considering these, it is worth noting that improving the insulation of your school buildings may be most cost-effectively undertaken as part of a refurbishment programme. In addition, a school's heating controls should be capable of responding to the improved thermal performance of the building fabric.

It is important to remember that a school functions as a complex system of interacting parts, including people, environment, plant and fabric.

Changing one aspect may influence another.

12.1.1.1. Roof insulation

The best way to insulate a roof depends on its construction. Pitched roofs with large, accessible voids are the easiest and cheapest to insulate.

This is usually straightforward and cost-effective and can be undertaken as a stand-alone energy conservation measure. Insulation is normally laid directly above the ceiling, but can also be placed at rafter level. In many schools, roof insulation may have already been added at some stage. However, if there is less than 50 mm of insulation, it would be worth upgrading to meet current standards by increasing the thickness to 150 mm.

Insulating a flat roof is far more complicated and expensive than insulating a pitched roof.

Generally, it will only be cost-effective to upgrade the insulation if the existing roof covering has failed and needs replacing or renewing. When a new roof covering is necessary, the opportunity to improve the insulation to current standards should not be missed. It may be 20 years before the opportunity arises again.

Many classrooms immediately below a poorly insulated roof suffer from overheating in summer; adding insulation to the roof can alleviate this problem.

12.1.1.2. Wall insulation

Heat loss through a cavity wall can be reduced at modest cost by insulating the cavity. Significant savings are possible and this is often a cost-effective investment. Insulation is inserted into the wall, in the form of loose fibres, beads, or foam. By maintaining the inside of the wall at a higher temperature, cavity insulation improves comfort and reduces the risk of condensation.

Improving the insulation value of other wall constructions is generally much more expensive.

Solid walls can have dry linings fitted internally or insulating renders applied externally. Schools with curtain walls can have insulating panels added to replace excessive glazed areas, with the additional benefit of reducing summer overheating.

12.1.1.3. Double glazing

Replacing single glazing in existing windows with double glazed units, or adding secondary glazing is rarely cost-effective as far as energy savings are concerned. However, double glazing has benefits other than energy saving, such as improved comfort, reduced sound transmission and a reduced risk of condensation. In some circumstances these other benefits may be sufficient to justify the expense of double glazing.

12.1.1.4. Reflecting foil behind radiators on external walls

Placing a sheet of insulated aluminium foil behind radiators is a simple low cost measure. It is cost- effective for all types of wall construction, but the largest returns can be expected on solid, uninsulated walls through which the rate of heat loss is greatest.

12.1.2. Air infiltration and ventilation

Air infiltration is the uncontrolled leakage of air through small gaps and cracks in the building fabric, such as at window and door openings, around skirting boards and at wall/ceiling junctions. Draught stripping reduces the rate of air infiltration.

Ventilation is the intentional replacement of stale internal air with fresh outside air. It is provided in one of two ways:

- openable windows or air vents - sometimes called natural ventilation;
- mechanical ventilation.

Ventilation is necessary and desirable and will always result in some heat loss. However, if in cold weather windows are habitually left open and fans left running continuously, not only is energy wasted, but the heating system may have difficulty achieving a comfortable temperature.

12.1.2.1. Air infiltration

Air infiltration is a major source of heat loss from school buildings. Cold air infiltrates through the cracks that surround all doors and windows. A door with a 3 mm gap round it will let in as much cold air as a hole in the wall about the size of a brick. Given the number of doors and windows in your building, the amount of cold air entering through gaps can be considerable. About a third of the heat used in winter to heat your school is to heat the incoming air. The rest passes through walls, windows, floor and roof.

12.1.2.2. Draught lobbies and door closers

External doors can be an important source of heat loss from school buildings. Where door closers are fitted, they should be kept in good repair as a means of minimising such loss. Frequent checks should also be undertaken to ensure that doors close properly without leaving gaps.

On main entrance doors a second set of doors can be fitted to form a draught lobby. These prevent energy wastage by reducing the volume of external air that has to be heated. While this measure can be effective, the cost of constructing new external draught lobbies is relatively high and they can have long pay-back periods.

12.1.2.3. Draught stripping

Unless windows and doors fit well or already have draught stripping, fitting draughtseals should be cost-effective.

A simple way of checking how well a window fits is to use the coin test. If you can push a coin having about 1.5 mm thickness between an opening light and the window frame, then draught stripping should prove worthwhile.

As well as reducing energy loss by cutting out air leakage, draught stripping has other advantages:

- Draughts. In winter, cold outside air leaks through the gaps between window and frame and, being denser than the warm internal air, sinks to the floor. This causes cold draughts at floor level and chills the feet and ankles. Even if the rest of the room is warm, draughts can cause discomfort.
- Noise and dirt. By sealing the gaps and reducing air leakage, draught stripping cuts down the amount of outside noise, dust and dirt that enters the building through the windows.

Draught stripping is very often the cheapest method of reducing the heat lost from a building.

The low capital outlay required means that the cost can generally be recouped from reductions in fuel bills within a medium pay-back period.

The objective of draught stripping is to eliminate excessive and uncontrolled air leakage, not to stop all ventilation with outside air. Controlled ventilation is necessary for the removal of odours, water vapour and carbon dioxide to produce a healthy working environment.

12.2. Increasing efficiency of equipment

12.2.1. Lighting

Lighting is the major user of electricity in schools.

Electric lighting is provided to supplement daylight and for use after dark, except in limited cases where exceptional educational needs or site limitations are best met by a deeper building form with some permanent supplementary artificial lighting.

The running costs of the electric lighting in schools commonly amounts to 30%-50% of the annual bill for fuel and power in terms of primary energy.

Taking advantage of recent developments in lighting technology can often reduce energy consumption by 30-60% for the same standards of lighting, especially where lighting installations are 10 or more years old.

This section describes four ways of cutting lighting costs by:

- replacing tungsten light bulbs with compact fluorescent lamps;
- upgrading existing tubular fluorescent lighting;
- using highly efficient high pressure sodium lighting in assembly and sports halls, and;
- improving switching arrangements.

12.2.1.1. Compact fluorescent lighting

If tungsten light bulbs are to be replaced by fluorescent lamps (compact or tubular) it is an ideal opportunity to **improve** the lighting level in your teaching areas.

Installing modern tubular or compact fluorescent lamps of a higher equivalent wattage than the existing lighting may enable you to improve your lighting levels **and** save electricity.

On average, tungsten light bulbs produce 14 lumens of light output for each watt of electricity consumed (the lumen is the unit of light available from a source). Compact fluorescent lamps produce up to 60 lumens per watt. They also last up to eight times as long. Even though the new lamps are more expensive than standard light bulbs, their overall running costs are about half those of tungsten light bulbs.

12.2.1.2. Tubular fluorescent lighting

The last decade has seen major developments in the standard fluorescent tubular lamp. There are three that every school should be aware of:

- The introduction of the slimmer 26 mm diameter tubes;
- the new electronic starter, and;
- high frequency ballast's.

The new 26 mm (1") diameter fluorescent tubes are usually filled with krypton gas instead of the argon gas used in the traditional 38 mm (1.5") tubes. The new tubes use about 8% less electricity than 38 mm tubes for the same light output, thus producing an immediate and permanent saving in running costs. The 26 mm tubes also cost slightly less to buy and can be used as a direct replacement for existing lamps in most switchstart light fittings without modification.

The switchstart light fittings are the most common type and are recognisable from the "starters" that plug into the fitting. You should replace the 38 mm tubes with 26 mm tubes as the former expire.

Fluorescent fittings with high frequency (HF) ballast's are the most efficient type of lighting for classrooms. They are more expensive to buy than the conventional fluorescent fittings, but have several advantages:

- energy cost savings - typically around 15% (compared with conventional wire wound choke ballasts);
- they eliminate the mains hum and flicker that can cause headaches and eye strain in some people;
- fast and reliable flicker-free starting;
- more stable operation that extends lamp life and light output.

12.2.1.3. Lighting for assembly and sports halls

Although fluorescent lighting can provide good, efficient lighting for these high ceiling rooms, high pressure sodium lighting (called SON) is often preferred. SON lamps are available in higher wattages (typically 150, 250 and 400 watts) than fluorescent lamps, so fewer fittings are needed and this results in a more economic installation.

However, if the hall is used for sports, care must be taken to avoid excessive glare from these high intensity lights. It is recommended that you seek advice from your lighting adviser prior to undertaking a major refurbishment of your sports hall lighting. If your hall has mercury discharge lights, consider replacing them with compatible SON lamps or replace luminaries completely.

This should give much better light output and lower running costs. SON lighting is very efficient and has a long lamp life - a big advantage in high ceiling installations. They do however, have "strike" and "warm-up" times that should be considered in relation to the occupancy patterns and switching arrangements.

12.2.1.4. Switching arrangements

The largest waste of energy in lighting comes from using lights unnecessarily; lighting areas that are unoccupied and using lights at times when daylight is adequate.

Switching arrangements should be reviewed especially whenever rewiring becomes necessary. Large savings can be made if lights are wired so that those closest to the windows can be switched separately from those furthest from the windows. For most classrooms, the ideal arrangement is for each row of lights parallel to the window to have its own switch.

This switching arrangement allows lighting to be used most economically in well daylit classrooms.

12.2.1.5. Automatic controls

Rather than relying on manual switching, it is possible to install automatic lighting controls such as presence detectors, photoelectric controls and timeclocks. These are likely to be most economic in larger schools, or those regularly used in the evenings.

12.2.2. The boiler room and heating system

The boiler room and heating controls are often the most fruitful and cost-effective area for investment in energy savings, especially when the installation is more than 5-10 years old.

All controls have to be properly installed and commissioned to operate effectively. However, many of the controls described above are relatively complex and work by performing calculations to determine how particular parts of a heating system should be operated for maximum efficiency. Because of this, if their settings are altered or tampered with, energy wastage can occur.

With management responsibility increasingly being devolved to schools, there is a growing demand for heating controls that can be easily understood and operated by school staff.

A simple control system which is easy to understand and operate may be preferable to a more complex, technically sophisticated system which operates automatically, but which may be vulnerable to uninformed interventions.

Space heating controls in schools should be reliable and wholly automatic. Adjustable components (such as thermostats) should be accessible only to authorised persons and should be tamperproof. Any installation dependent on manual control, for example by use of hand wheel radiator valves, is likely to prove unsatisfactory in respect of comfort or energy usage, or both.

12.2.2.1. Weather compensators

Compensators are heating controls that regulate the temperature of the hot water flowing through the radiators to compensate for changes in external temperature.

Compensators have to be sited in appropriate positions and be fully maintained to provide the greatest returns.

12.2.2.2. Optimum stop/start control

Optimisers are connected to sensors that measure the temperatures inside and outside the school. They use this information to calculate the optimum time to switch on the heating system so that the building is brought up to temperature at a set time (e.g. 8.45 am) with the minimum of energy use. Some optimisers also switch the heating off before school finishes, knowing that there is enough heat stored in the building to keep it warm until school closes.

Optimisers can make considerable savings especially in autumn and spring when the heating does not need to be switched on so early or stay on so late. Most schools are now fitted with optimisers. If your school does not have one, it is a very cost-effective investment. It should not be overridden manually or settings constantly changed, otherwise either energy will be wasted or the school will not warm up in time.

12.2.2.3. Zone controls

Schools that have a large building or several buildings on a site may benefit from fitting zone controls. Motorised valves can be fitted to the heating pipework as it enters each block and these can be programmed separately to switch the heating on and off as required in each zone. Zone controls can also be used to keep different parts of the school at different temperatures. For example gymnasium and sports halls only need to be heated to 15 °C, while classrooms should be heated to 18 °C.

Zoning of a school would be worthwhile if some parts are frequently used out of normal school hours, e.g. evening classes or sports facilities in use after school. Where the whole school needs to be heated out of hours, for a parents' evening for example, zone controls will not save energy. The most appropriate way of zoning your school depends on the particular pattern of use that you need to cater for. If the heating in your school is not already zoned, or is inadequately zoned, introducing zone controls may be a cost-effective investment, especially if suitable pipework is already installed, otherwise it may have a long pay-back period.

12.2.2.4. Energy management systems

A Building Energy management System (BEMS) offers the most sophisticated type of energy control. It is rare for energy management systems to be installed as an isolate energy conservation measure. This is more often done as part of a major programme for upgrading heating systems controls.

Building Energy Management Systems, use micro-electronics technology for the automatic monitoring and control of heating, lighting, electrical load and boilers. Such systems have the advantage that they can provide detailed information about the performance of a school's heating system, lighting and other equipment and costs to assist the management of the school.

An important feature of these systems is that they provide management information, as well as doing simple actions such as monitoring boiler efficiency, room temperatures, start and stop times etc. That can be just as easily done by less complex devices.

For example, a BEMS can keep records of energy use that can be used to establish fuel costs for catering (if sub-metered) or out of hours use.

Most BEMS in schools are currently linked to a central computer at the Local Authority headquarters. If an on-site Visual Display Unit and printer are provided, an energy management system can greatly enhance a school's ability to manage its fuel bill by allowing it to monitor the status of its heating and lighting equipment and plant, and its energy consumption. The statistical and graphical output provided by such systems can also usefully be exploited within the school curriculum.

12.2.2.5. Other controls

Room thermostats and thermostatic radiator valves are simple controls, but by regulating the temperature in a classroom or circulation space they can also save energy; 1 °C increase in a room's temperature will increase its heating bill by 6 to 10%. South-facing rooms, in particular, benefit from individual thermostatic control.

Overheating can be prevented by the thermostat shutting off radiators when the solar gains alone are sufficient to heat the room.

Most schools in colder climates will have a frost thermostat. This overrides other heating controls and switches the boiler on when the outside temperature falls below a specified level. The purpose of this is to prevent heating and other water pipes from freezing. It comes into operation during winter weekends and holidays when the heating is not required. Frost thermostats must not be set too high or heat will be wasted, nor must they be set too low or the system switched off, as frost damage may occur.

Set back controls reduce the temperature at which heated spaces are maintained overnight. They are most appropriate for schools that need continuous heating (e.g. boarding schools) or to avoid condensation due to excessive overnight cooling of the building.

12.2.2.6. Boiler sequencing controls

Some schools have several boilers fitted in parallel which can be called in to action individually. It is only in the coldest weather and in start up conditions that all the boilers need to come on together. Most of the time, some of the boilers can be switched off. The sequence control does this automatically, adjusting which boilers need to come into operation to meet the heating load. This increases the boilers operating efficiency and can result in significant energy savings.

12.3. Improving management and maintenance procedures

This seems the most interesting and promising area for a wide range of actions directed to reduce the energy consumption and cost in the school sector, which include:

- adopting measures for the management of systems and Good Housekeeping;
- organising a maintenance service directed to operate buildings and associated system with the best efficiency as specified in the design conditions;
- changing or modifying energy consuming equipment to use a less expensive form of energy;
- checking existing contracts for supply of fuel and electric energy, to attain more advantageous tariffs.

All these points are considered with necessary details in the **Guidelines** reported in Part Seven.

12.4. Evaluation of energy saving measures

The relative advantages of the various measures which could be undertaken in school buildings and systems may be evaluated considering pay-back period.

Four categories of measures have been here under considered:

- free measures;
- short pay-back;
- medium pay-back;
- long pay-back.

12.4.1. Free measures

12.4.1.1. Boiler room and heating system measures

- eliminate unnecessary running of boilers at weekends;
- eliminate holiday heating;
- ensure that controls are set to provide the temperatures you want at the times you need;
- ensure that the frost thermostat is set correctly;
- isolate winter boiler(s) and heating circuits in summer.

12.4.1.2. Other measures

- reduce domestic hot water temperature;
- isolate immersion water heaters during holidays;
- use swimming pool cover where fitted;
- replace 38 mm fluorescent tubes with high efficiency 26 mm tubes as the former expire (if you have switch start fittings).

12.4.2. Short pay-back (less then 2 years)

12.4.2.1. Boiler room and heating system measures

- recommission optimiser and heating controls;
- check that boiler air/fuel ratio is correct (as part of regular maintenance);

- fit boiler sequence controls;
- repair leaks on distribution mains;
- reduce use of supplementary electric heaters;
- install, repair or replace thermostats;
- insulate domestic hot water cylinders;
- provide additional heating controls for individual heaters.

12.4.2.2. Other measures

- reset domestic hot water thermostat and time switches and make tamperproof;
- blank off unused air grilles behind radiators;
- seal unused chimneys and ventilation stacks;
- fit reflective foil behind radiators;
- install time-switches for swimming pool circulating pumps;
- replace tungsten lighting with compact fluorescent lamps.

12.4.3. Medium pay-back (2-5 years)

12.4.3.1. Boiler room and heating system measures

- install modern instruments to control boiler burners and measure flue gas composition;
- discontinue night set back and install optimiser;
- install thermostatic boiler controls;
- improve/repair thermal insulation on the boiler;
- fit an optimiser and/or compensator;
- install a Building Energy Management System;
- install dual fuel burners to boiler;
- insulate pipework to heating system;
- fit timeclocks to hot water immersion heaters;
- replace central hot water boiler with point-of-use gas or off-peak electric heaters;
- fit thermostatic radiator valves;
- fit timeclocks to fan convector heaters;
- replace on-peak electric convector heaters with off-peak storage.

12.4.3.2. Other measures

- improve controls to storage radiators;
- install manual swimming pool cover;
- fit self-closing devices to external doors;
- draught strip external doors and windows;
- insulate loft spaces to current standards;
- install cavity wall insulation;
- install spray taps (soft water areas only) and automatic valves to showers;
- install water economy equipment to WC and urinal cisterns;
- install heat pump/heat recovery system, to swimming pool;
- control run times for extract fans;
- rearrange switching of light fittings.

12.4.4. Long pay-back (typically 5-10 years)

12.4.4.1. Boiler room and heating system measures

- improve zoning of the heating system;
- install new condensing boiler;
- replace electric (storage) heaters with gas-fired heaters.

12.4.4.2. Other measures

- replace electric water heaters with gas-fired heaters;
- install draught lobby to main entrance;
- install double glazing;
- fit secondary double glazing;
- replace excessive areas of glazing with insulated infill panels;
- insulate existing swimming pool roof and walls;
- install automatic swimming pool cover;
- install occupancy sensors to control lighting;
- replace old fluorescent fittings with modern efficient fittings, e.g. high frequency fluorescent fittings.

PART SEVEN - GUIDELINES FOR ENERGY EFFICIENT MANAGEMENT AND MAINTENANCE

13. OBJECTIVES OF THE GUIDE

This Guide has been prepared on the basis of the experience gained by the Working Group in three years activity, with the intent to give simple and practical directions for the energy saving oriented management and maintenance of the school building and associated systems.

It describes the importance of regular monitoring of fuel consumption and outlines the first steps which can be taken to cut out the wasteful use of energy.

A School is different from other organisations such as Hospitals, Commercial Buildings, Residential Buildings, and the like; in a school, normally there are no technical people, no specialists and no skilled personnel; therefore it is not easy to take initiatives to rationalise energy use, and their success relies mostly on the goodwill and enthusiasm of a few persons.

According to the experience gained in many countries, the main problem is to attain a change of mentality and of attitude, and to provide motivation.

Identifying good energy conservation measures is one thing, getting staff to change lifelong habits and pupils to follow good advice, is another. The long term objective in motivating staff and pupils must be to change attitudes and energy using habits gradually, so that the prudent use of resources becomes an instinctive part of every day behaviour.

All of us know very well that energy is wasted when we open the windows in an overheated room, when lights are left on unnecessarily, when doors are left open, when taps are dripping, when systems are operated at low efficiency, and so on: we have read and heard such sentences so many times, that one believes that it is a useless waste of time to repeat them, and that it is obvious that people know how to manage these problems in a proper way.

However, the mentioned bad habits are currently happening, in the school area, on a large scale, causing heavy energy losses and waste, which means that measures to prevent this need to be applied.

The aim of this guide is to provide school managers and operators with advice and methods and procedures, to operate their systems efficiently and thereby reduce their energy consumption and cost.

Apart from differences in building fabric and the condition of the plant, the energy consumption in comparable schools may differ considerably, due, in large part, to the manner in which space and equipment is used. For example a motivated, well trained caretaker can make a great difference to the amount of energy used in a school. The attitudes of staff, pupils and out-of-hours users to energy efficiency will also have a major bearing on the amount of energy consumed.

Similarly, energy savings can be made in schools by rescheduling timetables and holiday periods, or making use of teaching space for other purposes associated with education or community use. A great deal depends on the motivation of the occupants to save energy, the amount of information and training they receive, and the design of equipment, particularly controls.

When we consider the three main general lines suitable to attain reductions in the energy consumption in school buildings and systems, reported in § 12, we notice that while the first two require, for their implementation, availability of large amounts of money, the last one, related to management improvement, needs only the help of good-will and prepared personnel, with the support of very low investment.

The intent of this Guide is therefore to help the school personnel and pupils to adopt a way of life and a mentality open to new tasks and new objectives, directed more to manage efficiently the school systems, than to seek expensive alterations or modifications.

Keeping these objectives in mind, key functions are the following:

- monitor energy consumption using modern computer based systems;
- review fuel contracts and energy tariffs;
- disseminate good energy management practices, and support their adoption in schools;
- train key staff as caretakers;
- inform schools of their performance;
- investigate poor performance and recommend solutions;
- regularly report back on progress and advise on long term strategies.

14. GOOD MANAGEMENT PRACTICES

Energy management aims to achieve the required internal environment for the minimum energy cost.

The cost of the energy used to heat and light a school is an important fraction of the total budget over which the governing staff can exercise management control.

Saving energy is not just about capital investments, such as new boilers, extra insulation, substitution of equipment, etc., because major investments remain the responsibility of school Authorities.

The most rapid results in energy conservation come from improvements in "housekeeping" and from careful maintenance of both building and heating plant. These can give quick returns for low expenditure. Furthermore, energy saving features designed into the building in the first place may easily be enhanced or nullified by good or bad management practices.

It is important to motivate staff and pupils to adopt simple energy savings habits; this is the area referred to as "Good Housekeeping" which a school should tackle first to cut its energy costs.

Worthwhile reductions in energy consumption can be achieved in your school with its existing equipment and buildings, **without any additional financial investment.**

There are many reasons why "good housekeeping", e.g. switching off lights, turning off taps, etc., is a good way to start saving energy and there are very few, if any, buildings where no savings can be made. Good housekeeping:

- requires no capital investment;
- can be put into operation straight away;
- takes very little time - many tasks take less than a minute;
- gives cost, energy and environmental benefits that start immediately.

Good housekeeping is not a "do it and forget it" exercise. Monitoring and checking of temperatures, lights, meters, etc., needs to be done at regular intervals. Staff and pupils may require periodic reminding to maintain interest and motivation.

The following measures are those which mainly concern staff or pupils in their everyday use of a building. They are matters of common sense but they go a long way towards accounting for the difference in fuel bills between one building and another.

Good housekeeping mainly consists of:

1. Ensuring plant and equipment run at optimum efficiency by regularly checking operating performance and establishing a good standard of maintenance.
2. Educating and training staff about what is being done to save energy, why it is being done and what they can do to help.
3. Establishing the pattern of energy use and identifying the opportunities for reducing energy consumption.

14.1. Basic principles

A complex of actions directed to improve energy management keeping in mind the reduction of the energy expenditure, in all its aspects, must take account of some basic principles:

- any individual school should propose and develop its own energy saving programme, as each school represents a different and particular situation: type of buildings, of systems, of fuel: different size, location, number of teachers and of pupils, age of pupils, etc.
- It is important that a **coordinator** be appointed to be responsible for the complete programme;
- For an energy saving programme it is essential to have the complete knowledge of the school building and systems in which we operate; collection of drawings, description of systems, results of previous analyses, etc. should be available.
- Prior to starting an energy saving programme, with a set time schedule, and a set objective, it is essential to have the possibility to **measure** the energy flow: evaluate the amount of energy (both thermal and electric) consumed in the last two or three years; measure the energy consumed during the time in which energy conservation measures and procedures have been applied; if such actions have been

successful, the difference will give directly the amount of energy saving that the school has attained with the programme performed.

- This implies the existence and the practical availability of meters for fuel and electricity, as well as of people who can read and interpret the figures shown on the dials.
  It is therefore necessary that the **coordinator** receives copies of the bills for fuel and electricity purchased by that individual school.
- For successful results of the overall action it is necessary to involve all members of the school: teachers, caretakers, pupils.
- If the energy conservation actions carried out in a certain school attain positive results, there will be a cost saving: this amount of money can be evaluated by the interested Authority and delivered to the same school as a reward for their commitment and good behaviour.
  This money could be employed for buying computers, books, or other useful facilities for the life of the school.

14.1.1. The "School Energy Manager"

The most important steps are to get energy efficiency accepted as a policy objective and to assign someone, with interest and enthusiasm for energy matters, the responsibility for managing energy.

There is a strong incentive for the governing body to make someone responsible for the good management of the energy consumption of the school.

The key word is **Responsibility**; experiences in many countries demonstrate that it is difficult to positively carry out an energy saving programme without appointing a coordinator who is responsible for the total programme.

The best person to be a "School Energy Manager" will vary from school to school; it could be a teacher, caretaker, or interested parent, but awareness and enthusiasm for energy issues is an important qualification. The larger the school the more the responsibilities should be shared out.

A "School Energy Manager" could easily save the school 10-15% of its energy bill.

14.1.2. Awareness and motivation

Success in achieving energy savings is dependent upon peoples attitudes.

Often people do not realise that many of their actions can be wasteful of energy, e.g. leaving outside doors open or taps running, opening the windows in a room when the temperature is high, leaving lights on when leaving a room, etc. These wastefully practices can become habitual if there is no encouragement to change.

To be a success, energy oriented management relies on awareness and motivation.

Some essential activities to motivate staff and pupils include:

- creating energy awareness and enthusiasm to save money for the school;
- keeping staff and pupils well informed on developments;
- publishing and rewarding their energy saving achievements;
- training and suitable incentives for key staff.

Increasing energy awareness is the one aspect where the commitment of the School Energy Manager and Senior staff will have the greatest impact on energy costs.

14.1.3. Involvement

All members of a school should be involved in the energy saving activity.

The appointment of energy monitors is one way to improve energy awareness, and placing emphasis on environmental issues may be another way.

If teachers, caretakers, and others are required to take an increased responsibility for energy savings, then training will be necessary to extend their range of skill. Local Authorities and Energy Agencies, may play an important role in training.

Ideally training should take the form of a practical on-site session.

For example, setting heating controls, checking the combustion efficiency of a boiler, or simply changing the washer on a tap. As well as improving skills, training can increase confidence and encourage people to contribute more.

Incentives can help to obtain effort and cooperation that might not otherwise be forthcoming, and should be aimed at the whole school. Rewards or bonuses can be related to the size of energy savings achieved. The head and governors could promise the purchase of certain items of equipment (e.g. computers, musical instruments, gymnastic equipment) when the energy bill meets certain targets. To have maximum impact, the promised incentive should be something that will benefit as many pupils as possible.

There is no magic solution; **cooperation** is important, and seeking the active involvement of as many people as possible. Aim to capture their imagination and regularly publicise how much the savings are benefiting the school and the environment.

It must be realised that bringing down energy costs is the result of a team effort: in the schools we have three groups who play different roles, but should work together:

- **headmasters** and **governors**: have the responsibility of all actions conducted in the school;
- **caretakers** and energy managers: coordinate and monitor energy use, promote energy awareness amongst staff and pupils and keep up a good level of maintenance and housekeeping;
- **teachers**: must prepare children for what is foreseen as a much more difficult future: the problem is the education of todays' generation who to-morrow will take decisions.

15. ENERGY MANAGEMENT PRACTICE

The potential for schools to make significant savings with minimum capital outlay is real and should be encouraged in all schools.

As a result of the experience gained in programmes successfully carried out, we may identify eight steps to more efficient energy management in schools as follows:

1. **Get energy efficiency accepted as a policy objective** of your school's governing body.
2. **Assign individual responsibility for energy** within the governing body and the teaching staff (i.e. appoint a School Energy Manager).
3. **Involve your caretaker**; without his goodwill, support and experience, nobody else will be able to play their part effectively
4. **Conduct energy surveys** on school buildings and systems, in order to identify the energy saving measures to be applied
5. **Nominate pupils to act as energy (and water) monitors.**
6. **Monitor your energy consumption.** Read your meters. Check your energy bills for the past year and that you are paying for gas and electricity on the right tariffs. If necessary, seek advice.
7. **Keep people informed on progress.** Governors should receive a progress report at least once a year.
   Staff and pupils should be regularly updated in order to raise energy awareness and motivation.
   Set targets for savings.
8. **Don't forget the curriculum.** In both the short and the long term, your best investment is to raise the level of environmental awareness amongst your staff and pupils.

15.1. The energy balance

The first step of any energy saving programme is the preparation of the **Energy Balance**, considering the amount of energy supplied in all forms to the school building, and the amount of energy going out.

15.1.1. Energy in

Energy is usually purchased from three main sources: natural gas, fuel oil and electricity.

15.1.1.1. Natural gas

Natural gas is purchased on a cost per unit volume basis, usually m^3.. Energy content averages about 8,300 kcal (9.63 kWh) per m^3. Typical combustion efficiencies for furnace and boiler applications range from 80 to 90 percent, depending upon the age and type of equipment.

The efficiency figures represent that portion of energy from the gas which is transferred to the heating medium. The balance of the energy is lost up the chimney as hot air and combustion by-products.

15.1.1.2. Fuel oil

Fuel oil is purchased per unit of weight, usually in kg or litres. Energy content averages 9,500 kcal (11 kWh) per kg, and efficiencies range from 70 to 85 percent.

15.1.1.3. Electricity

Electricity is purchased on a per kWh basis.

In addition, a charge may be assessed based on how much electricity is consumed at any given time. This is called demand, and it is measured in kilo-volt amperes, or kVA. Demand is charged because the electrical utility must maintain equipment capacity to meet the peak loading demand of its customers.

15.1.2. Energy out

Now let's take a look at where the energy is going.

Fuel combustion energy is consumed as follows:

- as heat lost up the chimney of boilers and furnaces due to combustion inefficiency and heat exchanger design;

- as heat that escapes from uninsulated ducts or pipes. This energy is often not utilised in the occupied space and is lost to unoccupied space, crawlspaces and eventually the outside;
- as heat added to the school rooms to offset transmission losses through walls, roofs and windows;
- as heat added to raise the temperature of infiltration air;
- as heat added to the make-up air to raise its temperature to be compatible with the surrounding room temperature;
- as heat added to the domestic hot water which after its use leaves the building envelope through the sanitary drainage system.

Electrical energy is used in the following ways:

- to provide light;
- to operate business machines, audio systems, etc.;
- to operate machinery for moving air, pumping liquid, compressing gases, etc.;
- in the classrooms, labs and shops, electrical energy may be converted to motion or heat by the use of demonstration equipment, saws, lathes, sanders, ovens, heaters, etc.;
- in some schools, the energy is used directly for heating;
- in air-conditioned schools, electrical energy is usually utilised to operate the refrigeration equipment.

Although these energy use patterns are noted individually, they are often closely related. For instance, lighting equipment contributes to the heating of the school. The conversion of a lighting system to a more efficient type will be somewhat offset by the requirement to add heat from other sources. This is one example of how closely the various energy forms in a school are related.

This interrelationship must be assessed when energy conservation measures are being developed.

15.2. Preliminary energy analysis

An **energy audit** is the physical measurement of energy use in a building. Auditing analyses the data from meter readings and the information from the energy survey and allocates energy consumption to different uses and pieces of plant and equipment. Its purpose is to account for all the energy used and recommend where savings are possible.

An energy **walk-round** is a simple and cheap method that can be used as one of the first steps towards getting the energy consumption of the school under control and then keeping it there.

One objective of this analysis is to identify where low-cost energy conservation measures can be applied, mainly in the following two fields:

- good housekeeping;
- repairs and maintenance.

It is simply a tour of inspection around the school premises making a systematic visual inspection of each room and circulation area in turn, noting down where:

- energy is being wasted (i.e. good housekeeping practices are not being followed);
- repair or maintenance work is needed (to reduce energy costs)
- there is a need for capital investment (to improve energy efficiency)

This analysis may be made much easier by using simple check-lists, such as are reported in this chapter.

A walk-round inspection should be conducted in the following ways: the Head, the School Energy Manager and caretaker should team up to walk round the school, at monthly intervals (if possible) to:

- look for obvious waste;
- agree good housekeeping' measures, room by room; follow this up by explaining the reasons for the measures to all relevant staff and pupils;
- produce a list of items needing maintenance, servicing, repair or replacement;
- check progress on the next "walkround";
- establish priorities for investment. This is especially important if you want to integrate your priorities for action with the School Authority's own investment programme. Some energy saving measures can be installed at very little additional cost.

15.2.1. Good housekeeping checklist

Prepare a Good Housekeeping Checklist for each space and bring its contents to the attention of everyone who uses it: teachers, children, cleaners and extramural users.

Working area by area, use the checklist to note the specific good housekeeping practices which need to be followed in each space.

An example of such a checklist is here annexed: a copy may be used, in this case for the analysis of six different spaces.

The list may be expanded, with integration of more items, more rooms, or it could be reduced in scope, according to the specific needs and characteristics of the school considered.

This list was produced by **BRECSU**, Building Research Establishment, Garston, Watford, WD2 TJR, U.K.

15.3. Monitoring and targeting for energy efficiency

Monitoring and targeting is a management discipline which should be at the core of every energy efficiency programme.

Install enough sub-metering to monitor energy use regularly, analyse the figures and establish standards against which targets can be set.

Monitoring and targeting enables organisations to manage energy as a controllable resource in the same way as they manage other resources such as capital finance and manpower.

It is a powerful and flexible management approach, in helping to control and reduce energy consumption per unit of output so as to cut costs and release resources for other uses.

The essence of monitoring is that energy use is accurately measured, then compared with a set of standards, derived from a knowledge of the organisation's own capability, and then possibly further checked by reference to external norms.

Once the monitoring process is under way, targets are set to motivate all involved to seek an improvement in performance beyond the set standards.

By welding the control and motivational aspects of energy management closely together, M & T provides a structured framework in which managers at all levels are able to optimise efficiency through the careful use of the energy resources for which they are responsible.

Date of inspection..

Good Housekeeping
Checklist

	Make a schedule of spaces in your school and note items needing attention					
Action required when space is occupied						
• Check if there are complaints about comfort conditions	....	....	....	....	....	....
• Check room thermostat on correct temperature	....	....	....	....	....	....
• Check heating controls (e.g. thermostatic radiator valves) on correct setting.	....	....	....	....	....	....
• Switch lights off (if daylight sufficient)..............	....	....	....	....	....	....
• Close windows and door (if heating is on)	....	....	....	....	....	....
• Avoid use of portable electric heaters (except as a last resort)..............	....	....	....	....	....	....
• Avoid use of high energy consuming equipment, e.g. kilns,	....	....	....	....	....	....
during maximum demand period for electricity	....	....	....	....	....	....
• Avoid constructions in front of radiators or heaters	....	....	....	....	....	....
• Report if room is suffering from under or over heating	....	....	....	....	....	....
....	....	....	....	....	....	....
Action required on leaving space unoccupied						
• Switch off lights	....	....	....	....	....	....
• Close windows and doors	....	....	....	....	....	....
• Turn heating off (where non-automatic)	....	....	....	....	....	....
• Close curtains or blinds (at end of daylight)	....	....	....	....	....	....
• Turn off equipment and machinery, especially computers..............	....	....	....	....	....	....
•	....	....	....	....	....	....
•	....	....	....	....	....	....

Changing rooms and toilet areas

- Turn off hot and cold taps ....
- Turn off showers..............
- Switch off extract fans ....
- Turn off electric water heaters..............
- Check hot water temperatures..............

External lighting

- Switch night time lighting off when not needed..............

Swimming Pool

- Replace swimming pool cover..............
- Check pool and air temperatures regularly ....

16. KEY ACTIVITIES OF THE SCHOOL ENERGY MANAGER

The activities of the person appointed to be responsible for energy in a school may be generally described as follows:

- Motivate staff and pupils to adopt good housekeeping - shutting windows and doors, switching off unnecessary lights, turning off taps etc.
- Ensure that the heating system is running at optimum efficiency and there is a regular programme of checking thermostats and time clock settings, boiler maintenance etc.
- Identify where investments can achieve worthwhile energy savings, e.g. more energy efficient light fittings, better controls for the heating system, etc.
- **Monitor fuel consumption**
  Establish typical weekly consumption for electricity, other fuels (and also water). Don't just rely on energy bills (they could contain an estimate). Reading the meter on a regular basis will help to spot any abnormalities quickly. Check that fuel bills and tariffs are correct before authorising payment.
- **Cut out energy waste**
  Good housekeeping should be the first thing to be introduced to minimise waste. Aim to improve energy awareness in the school, e.g. each class can nominate pupils to act as Energy Monitors, hold poster competitions, integrate energy matters into the curriculum and project work. Report on progress and publicise how savings are benefiting the school.
- **Liaise with caretaking staff and energy specialists**
  The support and goodwill of the caretaking staff is crucial if the school is to achieve its optimum energy performance.

Some of these activities may be delegated to other members of staff.

The more people who get involved, the greater chance of success, especially when everyone has a clear area of responsibility.

16.1. Monitoring

Measuring energy consumption by taking meter readings is an essential part of managing energy costs. Regular monitoring can be useful to:

- check fuel bills are correct when authorising payment
- measure changes in consumption due to the introduction of new plant and equipment or energy awareness campaigns
- establish typical weekly consumption of electricity, gas, coal, water etc. so you can spot abnormal consumption
- check if spending is consistent with budget allocation.

The first step is to find the meters and establish the purpose of each one: remember that caution may need to be exercised, for example, when meters are "housed" in areas that are unsuitable for pupils to enter. There may be several electricity meters for different tariffs, "head" meters (used for payment) and sub-meters (to check how much fuel is used in a part of the school). For example, many school kitchens have a sub-meter to enable fuel for catering to be costed separately. Check that meter reference numbers correspond with those on the fuel bills.

Start a regular meter reading programme and consider organising a supervised rota of school pupils to help.

16.2. Comparison of energy costs

The results of energy consumption coming from surveys and monitoring should be compared with the available data which represent mean accepted values for energy use in schools.

The job of the School Energy Manager is to look behind those figures, analyse where energy is being used, and try to identify fruitful areas where energy costs might be reduced.

Check how much the school spends on each fuel and consider what the fuel is used for.

In most cases, in order to establish the breakdown of use within each fuel, it will be necessary to take regular meter readings and analyse the seasonal variations in consumption.

Charting the monthly fuel consumption can be used to identify trends in energy use, and what these trends might reveal.

After working out the annual cost of each fuel, establish what it is used for. For example gas is used for heating, hot water and catering. Electricity is used for lighting and power. For most schools it will not be possible to establish from the fuel bills the breakdown of use within each fuel. Only where there are separate meters serving different parts of the school (e.g. to the kitchens) will this be immediately obvious.

16.3. Factors that influence energy costs

The factors that affect the energy costs in a school include:

- winter temperatures
- fuel prices
- hours of use
- good housekeeping by staff and pupils
- the school buildings

Winter temperatures and fuel prices change from year to year. To enable a direct comparison of one year's energy performance with another, it is therefore necessary to make adjustments to compensate for these changes. These are explained below.

16.3.1. Winter temperatures

The recognised way of comparing one year's temperature with another is to use "Degree Days".

The fluctuations in energy used for heating during a period correlate closely with the Degree Days for that period.

16.3.2. Fuel prices

It is necessary to make adjustments for changes in fuel prices.

The prices used should be the average paid in the relevant year. Alternatively, it is a simple matter to compare consumption in terms of kWh, therms, litres etc. This avoids the distortion of fuel price movements, but an adjustment must still be made for winter temperatures to enable a direct year-on-year comparison to be made.

16.3.3. Hours of use

The effect of extending the hours of use of a school must be considered.

The normal hours of use of a school are not likely to vary much from one year to the next. However some schools are hiring out their buildings. Get to know the school's average weekly energy cost. You can then use a chart to estimate the amount to charge to cover the cost of heating and lighting during the extra hours of use.

Where the heating system is zoned, provide out of hours heating only to the areas being used, not to the whole school.

16.3.4. Good housekeeping

As already mentioned the adoption by staff and pupils of simple good housekeeping practices, such as keeping windows and doors closed during the heating season and turning off lights when daylighting is adequate, can reduce energy costs by 10% or more. Good practice in the maintenance and operation of the heating system and other services are equally important.

16.3.5. School buildings

Contrary to popular belief, the age of the school building has only a small influence on the energy costs of a school; there are good and poor energy performers for all groups. Of greater influence is the energy efficiency of the heating systems, light fittings and other plant and energy consuming equipment, how they are used and the standard of thermal insulation of the school buildings.

The energy efficiency of the school will largely reflect the level of investment in modern plant, equipment and insulation over the years.

The better the monitoring of energy use, the greater the certainty in evaluating the cost-effectiveness of investment proposals.

17. WHERE ENERGY CAN BE SAVED

Some examples are here reported of where and how good housekeeping measures can cut out waste and improve the efficient use of both fossil fuel and electricity.

Savings can be made in all areas of energy use.

It must be appreciated that energy use is the result of a complex interaction between the building, its occupants and the environment. The building must be considered as a system and the system must be understood fully.

Any measure to improve energy efficiency must not be considered in isolation; if the building envelope is insulated, the existing heating plant must be able to accommodate efficiently any reduction in demand for energy. Similarly improved insulation of an overglazed facade may involve reducing the window area which could, in turn, result in increased demand for electricity for artificial lighting.

Every building is different.

Techniques introduced during a refurbishment or remodelling exercise must take into account a number of factors including the type of building, its appearance, its construction, its physical condition and any changes in occupancy which may be planned. Moreover, the effects of energy saving measures are interrelated which must be taken into account if the full potential for savings is to be realised.

17.1. Heating

The cost of fuel used for heating is normally the largest single part of a school's energy bill. There are a few simple steps that, if followed, can result in valuable savings in your heating bill, often as high as 20%, if little attention has been paid to the heating system in the past:

- check that the heating system does not come on when the school is unoccupied, e.g. at weekends and holiday periods;
- aim to keep to the room temperatures specified. Overheating by 1 °C increases fuel consumption by 6-10%. Overheating by 3 or 4°C is not unknown;
- make sure that both the caretaker and the School Energy Manager understand how the heating controls work. This means being able to maintain them, and operate them efficiently;
- discourage the use of portable electric heaters; they are a very expensive form of heating;
- don't place obstructions in front of heaters and radiators. This reduces their effectiveness and efficiency;
- report areas that persistently suffer from overheating (correct by balancing radiators, and by adjusting any thermostat settings, if fitted);
- check room temperatures and thermostat settings regularly;
- check that the filters in fan convector heaters are cleaned regularly;
- staff and pupils should be encouraged to wear clothes that are suitable for the internal temperatures required by the Regulations;
- if separate zones of a building can be heated independently, the allocation of rooms for daytime (and any evening) use should be made so that plant is used economically and heat and light are not supplied to unused areas.

17.2. The boiler room

Saving money in the boiler room is largely a matter of routine and good practice both in operation and maintenance. The most important aspects are firstly, to make sure the controls are well understood and correctly set, and secondly that the boilers are regularly maintained. Whoever maintains the boilers should be adequately trained. They should know how to:

- check the combustion efficiency and flue gas temperatures of the boilers;
- sequence the boilers (where possible) to work at optimum efficiency. In mild weather it is more efficient to have one boiler firing continuously than two or more cycling on and off at low load.

17.3. Ventilation

Excessive and uncontrolled ventilation is often the largest source of avoidable wasted heat in a school - it can account for 60% of total heat loss. Hence one of the most important contributions that occupants can make towards reducing heating costs and greenhouse gas emissions is to avoid unnecessary opening of doors and windows during the heating season.

Up to half the money spent on heating a room is used to warm incoming fresh air. Heating systems are usually sized to be able to heat roughly twice the volume of air in a room up to the required temperature every hour (i.e. to cope with a ventilation rate of 2 air changes per hour).

Doubling this ventilation rate can increase your heating costs by 50%.

If you have extractor fans fitted in areas prone to high humidity (e.g. kitchens and shower rooms) these should be used, but only when the potential for condensation arises.

Remember, it is excessive and uncontrolled ventilation that you are trying to avoid. Some fresh air is essential for a healthy environment in your school.

17.4. Hot and cold water

The water supply to most schools is metered. The more water you use, the more it costs. So it pays to attend to leaks and dripping taps promptly.

Undetected leaks on underground mains can easily increase the water bill, so regular checking of meter readings is important, especially following cold and frosty weather. Meter readings before and after unoccupied periods, will help detect leaks.

It is often worthwhile to fit flow restrictors to taps serving wash basins. These help to reduce water consumption, while still providing an adequate flow for hand washing.

If your main heating boilers are used to provide hot water in the summer there may still be ways of saving energy. For example, it may be possible to shut down all but one boiler or to use special controls to improve the efficiency. You will need expert advice to ensure that this is done safely.

17.5. Lighting and electrical power

Daytime electricity is expensive, so reducing electricity consumption should be high on your priority list. If you still have the older 38 mm diameter fluorescent tubes in fittings with the "starter" switch on the side, replace these with the higher efficiency 26 mm diameter tubes as and when the former expire or as part of routine maintenance. They cost no more, but use 8% less electricity.

Consider replacing tungsten light bulbs with compact fluorescent lamps. The higher initial cost of these lamps is more than offset by 75% lower electricity costs. Overall running costs are about half those of tungsten light bulbs.

It is a myth that it is cheaper to leave lights on (e.g. over playtime) than to switch them off. Lights in unoccupied rooms should always be switched off (unless they are only going to be off for a couple of minutes).

Make use of daylight wherever possible. Where lighting is necessary and light switches allow, switch perimeter lights nearest the windows off and only use those in the deepest and darkest part of a room. Where lighting quality is concerned, you may wish to seek specialist advice.

Make some one responsible for switching lights off at break times and at the end of the school day.

17.6. Swimming pools

If your school has a heated swimming pool, you need to take particular care in controlling the temperature of its water. A pool is expensive to run because it has to be continuously heated. The temperature of the pool's water is the main factor that governs the amount of energy it uses. Keep a close check on this, or it can quickly consume money you've earmarked for other purposes. For example, in a large comprehensive school, a small, poorly controlled pool can cost more to heat than the whole of the rest of the school. Even in schools where the pool's temperature is under better control, it is still likely to consume about a quarter of the school's energy use overall.

A regular check on your pool's water and air temperatures could form part of a science project (bear in mind that the pool will take time to warm up or cool down). The two processes that dominate energy use in any indoor pool are the evaporation losses from the pool surface and the ventilation losses from extracted air. These two are interlinked. In simple terms, evaporation, and hence condensation, are both minimised by keeping the hall air temperature approximately 1 °C higher than the water temperature. If the water temperature is higher than necessary you are likely to add to your energy costs twice - a higher water temperature requires a higher air temperature.

Routine use of a cover is an effective way to reduce your pool's energy costs. As a minimum, put the cover in place every evening and only remove it just before use. It is also worth putting the cover on your pool over lunchtime and even between lessons, if this can be achieved without incurring extra staff costs. The savings from using a cover on a heated outdoor pool are even greater than for an indoor pool.

Failure to use the pool cover diligently could raise your energy costs by as much as 50% (the cost of a pool cover can often be recouped in less than one year).

17.7. School cleaning

Whenever possible, cleaning should be carried out immediately before or after the school is occupied, then the pre-heating or residual heat can be used to provide adequate background heating. During the heating season, if cleaning has to be done at other times, it can prove expensive to heat the whole building for a small number of people.

Cleaning staff should be asked to keep windows and doors (including internal ones) closed at all times. This is particularly important if cleaning is done during the pre-heating period when the heating system is bringing room temperatures up to comfort level.

18. IDENTIFY INVESTMENT OPPORTUNITIES

Before investing in any technical measures to reduce your school's energy consumption, it is important to ensure that you are getting the best performance from what you already have, and that fuel charges are set at the lowest available tariffs from the utilities.

As already pointed out, good housekeeping and good practice in the operation and maintenance of equipment are the most effective ways of reducing energy costs.

Investment in energy saving equipment has to be seen as an addition to, not a substitute for, good energy management practices.

There are many technical measures that can improve the energy performance of school buildings, for example, fitting more sophisticated controls to the heating systems, or adding extra insulation in the roof space.

The table lists a wide range of technical measures that are appropriate for schools. They are compiled from the recommendations contained in the energy surveys of 145 schools in U.K.

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It is useful for the School Energy Manager to be aware of the options for incorporating new more efficient equipment into the school when the opportunity arises, for example, when the school buildings are due for refurbishment, or an item of plant or equipment needs replacing. However due to the interaction of many technical measures, correct design and installation are essential.

For the majority of schools, the building structure, together with the heating system and electrical services, are the responsibility of the School Authority.

As a result, while the school may be able to fund small investments out of energy savings (lamp replacement for example), major technical improvements need to be organised and financed by the appropriate department in your Local Authority.

Funding arrangements vary widely between Authorities, and you should find out what arrangements yours has for financing energy saving.

Not all energy saving investments will be cost-effective against your usual criteria, but many are likely to be so. But remember that factors other than energy savings, such as reduced maintenance, improved reliability or better comfort conditions, can be just as important in ensuring the financial viability of a project.

Table 6 - ENERGY SAVING MEASURES WORTH CONSIDERING

	Measure	Aim
Windows and doors	Draughtproof round windows and doors Fit automatic door closing devices	Reduce air infiltration
	Install draught lobbies Fit weather-stripped double glazing during refurbishment	Reduce air infiltration and rate of heat loss
	Reduce excessive glazing area by fitting insulated infill panels	Reduce rate of heat loss
Walls and roofs	Insulate roof voids Insulate cavity walls Insulate flat roofs (during refurbishment) Add internal insulation to walls	Reduce rate of heat loss
Boilers	Improve insulation to boilers and pipework	Reduce heat loss and improve operating efficiency
	Replace old inefficient boilers	Improve operating efficiency
Controls	Install zone controls, especially for areas with extended hours of use	Reduce heating domand and/or avoid overheating
	Install weather-compensating controls Install tamperproof thermostats	Reduce operating periods
	Install optimum start control to reduce pre-heating times	Reduce electricity demand
	Fit time controls to eliminate out of hours heating Fit time controls to kitchen and toilet extraction fans Consider installing a simple Building Energy Management System for larger premises	Improve comfort, reduce heating demand, avoid overheating and reduce operating periods
Water	Insulate hot water storage tank and pipework	Reduce heat losses
	Install spray taps	Reduce hot water demand
	Fit swimming pool cover	Reduce heating demand
Lighting	Install more efficient lighting or improved switching arrangements Install automatic lighting controls (time, daylight, occupant detection)	Reduce electricity demand
Heat recovery	Install heat recovery devices in existing ventilation exhaust system Consider installing a ventilation heat recovery system	Reduce heating demand by recovery reject heat

19. MAINTENANCE

The concept of maintenance includes all actions directed to keep all components of school buildings and associated systems in the good conditions required to operate safely and efficiently as foreseen by the design conditions.

19.1. Repairs and maintenance Checklist

Use a Repair and Maintenance Checklist as here annexed to identify work that needs to be done in each part of your school. Work out which items are your responsibility as "tenants" and which are the responsibility of your School Authority as "landlord". Put each set of items in priority order. If the School Authority has a rolling programme of maintenance or refurbishment work, compare your list with the one already drawn up for your school, and identify any opportunities for incorporating energy efficiency measures.

While working area by area make a list of all the items needing repair, maintenance, replacement or up-grading, remembering to look both inside and outside your building(s).

19.2. Electrical system maintenance

The reasons for maintenance of electrical services are the same as for any other aspect of property maintenance in the education sector, and are:

- to ensure the health and safety of the occupants;
- to prevent expense/costly damage;
- for maintenance other than health and safety, such as energy efficiency;
- to provide appropriate facilities for education.

Doing nothing and waiting until a failure has occurred will not ensure safety and will not meet the requirements of the law or published guidance. To comply with these, certain maintenance work must be planned and its actioning recorded. Safety must be given the highest priority.

The maintenance requirement determined at design and specification stages will not necessarily be the same as that required at some later time during the life of the installation. Indeed no fixed period can be defined for the life of an installation, as many unknown factors will influence it, including degree of usage, quality of materials and their life span. Consequently it is necessary to inspect and test electrical services and carry out condition appraisals; to assess maintenance needs and determine priorities a strategy for maintenance of electrical services must be established which addresses the matters considered above and includes:

- Record Documentation and Systems.
- Inspection and Testing.
- Condition Appraisal.
- Maintenance Requirements.
- Works Procedures.
- Educational Requirements.
- Energy.
- Community Use.

Each of these aspects is considered in greater detail in the following sections.

19.2.1. Record documentation and systems

Records are required if for no other reason than as a possible way of demonstrating, in the event of an incident, that all reasonable maintenance has been done.

However, records have a more useful purpose than this defensive one: they are a useful tool in facilitating planned maintenance, in determining work required, programming, monitoring that work was done, its cost and effectiveness.

By providing installation detail and historical data, records can also assist in future inspection and testing, and in fault finding and repair.

Record systems should be of a type that is easy to update. They should also make possible easy monitoring of trends in the condition of installations.

19.2.1.1. Minimum requirements for an equipment record

- Manufacturer's details and name plate details of any equipment.
- Manufacturer's maintenance recommendations.

- Manufacturer's spare parts list.
- Details of fuse link ratings and relay settings.
- Drawings giving "as-fitted" details and design data such as circuit and conductor size.
- History of what work has been carried out and what faults have occurred.
- Condition assessments.

19.2.2. Inspection and testing

Many electrical services comprise items which do not require regular routine attendance, e.g. cables, miniature circuit breakers, accessories, etc. in the same way as is required for mechanical services such as boilers, pumps, etc. However, all electrical services require to be continually monitored on a regular basis to detect deterioration so that timely repair can be carried out and any need for replacement, of part or all, identified.

Consequently, monitoring is the fundamental and major part of the maintenance of electrical services. This is achieved by visual inspection and electrical testing.

With regard to the safety of electrical installations, a great deal depends on inspections, tests and keeping of records.

The frequency of inspection and testing varies according to the usage and type of installation; Table 7 shows typical requirements. A competent person should determine how frequently inspection and testing are needed.

Table 7

INSPECTIONS AND TESTS

Frequency	Description
Weekly	Fire alarm functional test
Monthly	Emergency lighting functional test "Stop" button systems test
every 3 months (and after every alteration)	Stage lighting comprising portable dimmer racks with no fixed cabling: test as for temporary installation by competent person Fire alarm: maintenance by competent person
every 4 months	Inspect portable appliances
every 6 months	Emergency lighting: 1 hour duration test Central systems: batteries and power supplies checked Lifts: thorough examination by competent person Intruder alarms: routine maintenance by installers
Annually	Fire detection and alarm systems: maintenance by competent person Emergency lighting: inspection and test (after 3 years) Stage lighting: inspection and test by competent person Lightning protection: inspection and test by specialist contractor Portable equipment: inspection and test by competent person Pottery kilns: inspection and test by competent person Swimming-pool installations: inspection and test by competent person
every 3 years	Kitchens, laboratories, pottery, metal and woodworking areas: inspection and test by competent person Emergency lighting: inspection and test by competent person Electrical controls associated with mechanical plant: inspection and test by competent person
every 5 years (or more frequently as determined by competent person)	All other parts of electrical installation to be inspected and tested by competent person.

19.2.3. Condition appraisal

Condition appraisal requires some objective measure of the current condition of an asset. With electrical installations the assessment will be carried out by reference to two sets of information. The first is the results of inspection by a suitably qualified person of those parts of the installation that are accessible; it is the nature of electrical installations that much is hidden, either buried in walls, and floors or installed within voids, and to maximise safety much of the installation is deliberately inaccessible. The second set of information is the results of tests designed and carried out to ascertain the electrical integrity of the system as a whole or in part.

Systematic, uniform and objective methods should be adopted for evaluating maintenance needs and determining priorities, on the basis of the assessed condition of the electrical services. The aim of the assessment is to provide information from which it should be possible to extract the data necessary to prepare the planned maintenance schedule for up to five years, together with management information for general budgeting and planning.

NOTIONAL EQUIPMENT LIFE

EQUIPMENT	YEARS
Main switch gear	15-25
Main distribution wiring	25+
Distribution boards	25+
Final sub-circuits	25+
Local isolators	15
Socket outlets	15
Lighting	10-15
Mechanical equipment controls	10
Energy management control systems	7-10
Alarm systems	5-10

19.2.4. Maintenance requirements

Earlier sections have dealt with the necessity of carrying out regular inspections and tests to assess the safety and electrical integrity of installations.

Given that the primary requirement for maintenance of electrical systems is safety, followed by optimisation of economical life, it is not possible to make precise recommendations for the inspection intervals required under all circumstances.

19.2.5. Maintenance works procedures

There are two aspects to maintenance work: the specific maintenance task to be performed, and the procedure by which the task is carried out. It is essential to consider the competence required of personnel who will carry out electrical maintenance work from both viewpoints, and how safety, standards and quality will be ensured.

Procedures for carrying out maintenance work must ensure the safety of all, including the operative performing the task.

Although planning will ensure that best use is made of holiday periods, much electrical maintenance work will have to be carried out while the school is in use. This raises practical problems such as keeping the work area safe and preventing unauthorised persons from coming into contact with, or even approaching, live conductors. This will mean the use of barriers to segregate staff and pupils from work areas.

19.2.6. Educational requirements

Where possible, maintenance works should be planned and directed, not only to enhance the safety of the installation, but also to provide for the increasing educational demands on the electrical installation.

Curriculum development and use of information technologies have increased workplace demands for electrical equipment in the classroom. Many changes in education reflect the increased demands, experienced by businesses and commerce a few years ago, for equipment requiring electrical and signal cabling. As in these cases, the use of such equipment improves the range of opportunities available in education.

19.2.7. Energy

One common problem is that in many establishments energy invoices are settled and priorities for energy conservation work set separately from the planning and carrying out of maintenance works.

Expenditure on maintenance has a direct link to expenditure on energy. One of the prime objectives of maintenance should be to promote energy efficiency.

Any inspection and testing which indicates that remedial work is necessary should be carefully considered; cost and usage benefits can be obtained by replacement of existing systems by designs employing equipment and systems which use energy more efficiently.

A high priority should be to replace any existing filament lamps with compact fluorescent types, followed by replacements of standard fluorescent fittings with newer more efficient types.

Lighting controls are available; however, they need to be very flexible and sophisticated to be able to achieve real energy efficient use and provide the occupant with the right quality of lighting environment.

Apart from a zoned approach for both lighting and heating controls, consideration should also be given to the installation of more detailed metering of both heat and electricity consumption, particularly if the premises are used by other organisations outside normal school hours. This detailed metering would help in energy management by the school's staff in the early identification of poor control, as well as allowing accurate cost recovery from other users. However, a cost-benefit evaluation must be undertaken.

19.2.8. Community use

Increasingly, school facilities are being used outside normal hours for community use.

These uses include sports activities, adult education courses, religious use, polling stations or other community activities.

There may be different requirements of systems for community use and for educational needs, and it is unlikely that the entire premises will need to be used for community activities. In all future maintenance works on the electrical systems, consideration should be given to this type of change in use. In particular the lighting system should be adaptable for use only in those parts of the premises that will be used in the evenings, such as a small number of classrooms and the corridors and toilets that are associated with them.

Zoning of intruder alarm systems and environmental controls should also be considered, to take into account part use of the buildings.

To allow accurate costing of these community uses, the electrical systems should be adequately metered.

19.2.9. Maintenance tasks for staff

It must be stressed that anybody carrying out work on or near electrical systems and equipment must be competent to do so.

If staff are to contribute to the maintenance requirements safely, it will be necessary for them to undergo suitable training and to provide for each location short but detailed instructions, particularly about action to take in typical or emergency situations.

A list of possible staff maintenance tasks follows in Table 8.

Staff should remain vigilant over any obvious signs of damage, vandalism or incorrect operation.

Table 8 - POSSIBLE STAFF MAINTENANCE TASKS (AFTER SUITABLE TRAINING)

EQUIPMENT OR SYSTEMS	TASK
Main switchgear	• Inspection of switchgear/switch room on daily basis with emphasis on cleanliness, potential hazards such as water leakage, abnormal noise or overheating and security of the location. • Record meter readings for energy analysis by others. Look for any indicating lights that have changed status/appear to have failed, check the actual status if possible and take appropriate action. • Carry out any functional safety tests such as checking RCD self test every month. • Provide assistance to maintenance contractors whilst on site. This could involve remaining with the contractor's operative whilst work is carried out and will certainly entail providing access to secured areas such as switchrooms.
Distribution wiring	• Observation for mechanical damage and reporting back of problems. Particular attention should be paid to equipotential earth bonding. • Provide maintenance operatives with any personally known information.
Distribution boards	• Check to ensure security, functional test of RCD test button or other safety system.
Final subcircuits	• Observation and reporting of faulty or damaged circuit accessories like socket outlets, light switches etc. Switching off/making safe damaged equipment.
Lighting: stage	• Alteration to installation of lamps etc.
main	• Isolation of lighting circuit and replacement of lamps. This could be either a simple replacement on failure or a bulk relamping. • Cleaning of diffuser/controller, in conjunction with above. • Disposal of small quantities of failed lamps.
emergency	• Regular functional testing and recording of tests
Control systems	• Programming of controls for different uses of building. • Resetting time switch after power failure • Noting and reporting of faults • Recording of energy readings • Overriding of systems/manual control
Mechanical services controls	• Cleaning exterior of cabinets • Simple functional tests • Simple safety tests • Recording of plant settings and energy information • Setting and overriding of time switches
Fire alarms	• Daily inspection of control panel • Recording and reporting faults • Weekly test, each initiation point to be checked every 13 weeks
Intruder alarms	• Setting and turning off system • Identification of simple zone faults • Maintain secure, accurate records • Partial setting to allow out-of hours use
Portable equipment	• Fitting of plugs • Brief visual inspection each time equipment is used • Record keeping associated with annual inspection and test
Lightning protection	• Observation and report of damage
Lifts	• Observation and report of damage • Simple safety and functional tests

Date of inspection..

Repairs and Maintenance
Checklist

Item	Make a schedule of spaces in your school and note items needing attention					
• Install/repair/replace thermostat						
• Install/repair/replace thermostatic radiator valves						
• Clean air filters in fan convector heaters						
• Install/repair/replace controls to heating (specify the control)						
• Install/replace draught seals to doors and windows						
• Seal permanent ventilation opening (**older premises only**)						
• Install/lubricate/adjust door self-closing mechanism/hinges						
• Clean windows and rooflights						
• Replace demanged glazing						
• Repair/replace damaged window frames						
• Clean lamps and light fittings						
• Replace flickering fluorescent tubes						
• Replace 38 mm fluorescent tubes with higher efficiency 26 mm tubes						
• Consider replacing tungsten bulbs with compact fluorescent lamps						
• Install/rearrange/reposition switching/controls to lighting						
• Install/top up insulation in roof space						
• Install/replace insulation to pipework						
•						

Boiler/Plant Rooms

- Service/replace boiler(s)................................
- Check combustion efficiency and flue gas temperatures of boiler(s) ....
- Check/reset time clock settings ....
- Check sequencing of boilers (where appropriate) ....
- Install/reposition/replace insulation to hot water cylinder ....
- Install/reposition/replace insulation to pipework ....
- ....
- ....

Changing Rooms/Toilet areas

- Install over-run timers to extract fans ....
- Repair dripping tap(s) and shower(s)................................
- Repair overflows from storage cisterns ....
- Install water saving controls to urinals................................
- ....

Swimming pool

- Install/repair/replace cover to swimming pool ....
- ....

20. CONCLUSIONS

1. The IEA Working Group, set up in 1992, continued the earlier work of the Annex XV, on Energy Efficiency in Schools. It provided a forum for exchange of ideas between building professionals from different countries on improving energy efficiency of schools.
2. In all member countries, schools spend a significant part of their budget on energy. Hence any savings in use of energy would make a valuable contribution elsewhere in the schools.
3. Saving energy also reduces the "Greenhouse Effect". Following the Rio Earth Summit in 1992, most countries are developing environmental action plans and by using less energy schools will help:
   - create a healthier working environment
   - reduce demand on the world's finite energy sources
   - cut pollution. Every year the energy used to heat and light each classroom produces approximentely four tonnes of carbon dioxide.
4. Members of the Group have developed environmental assessment methodologies and green labelling has been introduced. European and national environmental and health and safety legislation has proceeded apace and revised standards of thermal insulation have been set by member countries.
5. The Group held six seminars, as described in the report.
   Much useful information produced by individual member countries has been disseminated which has saved a lot of duplication of effort and has allowed each member to become aware of the best practice and the design ideas of other member countries.
6. A wide ranging discussion took place between members of the group on energy saving in schools and clear strategies for school designers and users have been identified.
   For new schools passive solar design is felt to be the best solution. However most school buildings are existing and therefore refurbishment and upgrading offer the greatest scope for energy savings.
7. Sound methods of financial planning and management including accurate cost benefit analysis have been shown to be as important as sound technical solutions. Schemes offering financial support for energy efficient design with good pay back periods continue to attract attention. Authorities are recognising that energy saving schemes can give better financial returns than many more orthodox investments and are now prepared to support well presented business cases.
8. School managements' (Headteachers and Governors) attitudes are most important if savings are to be maintained over the years. Saving energy is not difficult. It takes only enthusiasm and leadership. The enthusiasm comes from having a clear vision of your goal and good leadership makes sure everyone is striving towards the same goal. About 10-20% savings can easily be achieved by schools through "Good Housedeeping" measures and regular maintenance. The following is a simple Action Plan that can be introduced in all schools.
   a. Headteacher and Governors take an overview of current energy use and agree targets for savings
   b. An energy manager is appointed
   c. An Action Plan is prepared and resources allocated
   d. The Action Plan is implemented
   e. All energy is bought at the best price on the cheapest tariff and after investigating alternative suppliers
   f. A regular check is kept on the peak demand for electricity
   g. A programme of staff training is introduced
   h. Pupils are involved and energy conservation incorporated in the curriculum

9. Energy awareness is beginning to play an important part in the school curriculum. This puts energy conservation into a global perspective with the other environmental issues. Children's enthusiasm for green issues is built upon by involving them directly in the school as a living laboratory for the study of energy and ecology. Doing this will ensure that future generations come to regard energy as a valuable and scarce resource.

10. Members of the IEA Working Group plan to continue an informal Forum for exchange of ideas on energy efficiency in schools.

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- BRECSU, the Building Research Energy Conservation Support Unit at the Building Research Establishment, U.K. The section of the report on *Guidelines for energy efficient management in schools* draws on the advice in their best practice publications for schools, in particular their Good Practice Guides and Energy Consumption Guides. For further information contact the Enquiries Bureau, Building Research Establishment, Garston, Watford, WD2 7JR, UK.
- CREATE, the Centre for Research Education and Training in Energy, 18 Devonshire Street, London, W1N 2AU, for writing the section on "Energy Efficiency in the Educational Curriculum".
- DFE, the Department for Education, Architects and Building Division, Schools Organisation Branch, Sanctuary Buildings, Great Smith Street, London, SW1P 3BT.
- O.E.C.D. - Program of Educational Buildings, 2, Rue André Pascal - PARIS - Report of the Seminar on Educational Buildings and Environment, by Dr. R. Othel.