European Commission

New Solutions in Energy Utilisation

The guide to

Sustainable energy technologies for schools

ENERGIE

ENERGIE

This ENERGIE publication is one of a series highlighting the potential for innovative non-nuclear energy technologies to become widely applied and contribute superior services to the citizen. European Commission strategies aim at influencing the scientific and engineering communities, policy makers and key market actors to create, encourage, acquire and apply cleaner, more efficient and more sustainable energy solutions for their own benefit and that of our wider society.

Funded under the European Union's Fifth Framework Programme for Research, Technological Development and Demonstration (RTD), ENERGIE's range of supports cover research, development, demonstration, dissemination, replication and market uptake - the full process of converting new ideas into practical solutions to real needs. Its publications, in print and electronic form, disseminate the results of actions carried out under this and previous Framework Programmes, including former JOULE-THERMIE actions. Jointly managed by Directorate-General Energy and Transport & Directorate-General Research, ENERGIE has a total budget of € 1042 million over the period 1999 to 2002.

Delivery is organised principally around two Key Actions, Cleaner Energy Systems, including Renewable Energies, and Economic and Efficient Energy for a Competitive Europe, within the theme "Energy, Environment and Sustainable Development", supplemented by coordination and cooperative activities of a sectoral and cross-sectoral nature. With targets guided by the Kyoto Protocol and associated policies, ENERGIE's integrated activities are focussed on new solutions which yield direct economic and environmental benefits to the energy user, and strengthen European competitive advantage by helping to achieve a position of leadership in the energy technologies of tomorrow. The resulting balanced improvements in energy, environmental and economic performance will help to ensure a sustainable future for Europe's citizens.

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The Guide to Sustainable Energy Technologies for Schools
is available in English, French and Portuguese.

The guide to

Sustainable energy technologies for schools

New solutions in energy utilisation

Energie-Cités

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Introduction

School buildings differ from other types of buildings because they are where our children are educated and have the opportunity to learn how to become environmentally-aware citizens.

It is therefore essential that schools set a good example regarding efficient fossil energy utilisation, pollution control, environmentally-friendly material selection, quality of life, users' comfort, etc. These experiences can serve as teaching aids for educational developments to raise awareness about different energy resources and their possible sustainable use.

All European municipalities have some involvement in managing, retrofitting and/or building schools. They are also concerned about balancing the municipal budget. Some existing schools have very high energy consumption due to poor design, operation or maintenance. Such schools would clearly benefit from energy efficiency improvements. New schools, if properly designed and constructed, can achieve extremely low energy use. Hence, there are significant attractions for municipalities to opt for sustainable solutions which involve energy efficient technologies and measures.

This is the challenging background which led to the production the Guide to Sustainable Energy Technologies for Schools. This guide is a decision-making tool intended for European municipalities and school managers. Its aim is to:

- assist them in choosing between the energy technologies that will be used in school building or retrofitting projects,
- provide them with a framework for measuring and comparing different aspects of energy performance that can be used to convince decision-makers to select sustainable energy technologies and measures.

The guide is composed of three parts:

- An illustrative list of sustainable energy technologies,
- An introduction to energy performance indicators,
- Fifteen case studies describing practical sustainable energy solutions applied to schools in seven European countries.

This guide was produced by Energie-Cités, Sheffield Hallam University and the National Association of Portuguese Municipalities in collaboration with a group of European local authorities. During the course of its preparation three Workshops were held to disseminate experience and good practice: in Grenoble (France), Newark-on-Trent (United Kingdom) and Coimbra (Portugal)).

The Guide to Sustainable Energy Technologies for Schools is available in English, French and Portuguese.

Contents

Sustainable **energy technologies** and measures

A list of sustainable energy technologies and measures is provided to stimulate building owners to consider integrating energy efficient technologies into their new school building and/or retrofitting projects. This illustrative list includes "hard" technologies (energy efficient materials, energy management systems, small-scale combined heat and power, etc.) as well as "soft" measures that are part of any project (appropriate financing and project accounting, environmentally-friendly supply chain decision, user involvement, etc.)

Each technology is symbolised by an icon that is repeated throughout the guide for ease at identification in the case studies.

Procurement
- terms of reference applied to new school buildings.

Building design
- building orientation, bioclimatic factors , passive heating and cooling
- space planning, internal space distribution

Knowing one's own urban (built) heritage
- energy audit

Building envelope
- building and insulation materials with high thermal performance
- or / and environmentally-friendly/ sustainable materials
- windows

Heating and domestic hot water appliances
- heat production autonomous or linked with a district heating network
- high performance or low consumption boiler
- small-scale combined heat and power
- thermal solar collector
- biomass boiler

Distribution and emission of heat
- low temperature underfloor heating
- warm air heating

Air-conditioning equipment
- methods for avoiding or limiting the use of air conditioning
- production, distribution and supply of cooling

Equipment to produce and distribute electricity
- photovoltaics
- wind energy
- green energy supply
- power limiting devices

Ventilation equipment
- natural ventilation
- mechanically controlled ventilation
- double flow
- adjustable (to the needs of the users)

Lighting equipment
- daylight
- lamp, reflector
- lighting management

Rational use of water
- water saving bathroom equipment/ appliances
- low water use toilets
- use of rain water

Modes of function of the equipment
- regulation
- programming
- remote control
- load management/ optimisation
- energy teams/ supervisors

Other equipment
- kitchen appliances
- washing machines
- pottery kiln
- other

Financing
- contracting
- third-party-financing
- other

Interaction with users
- teachers and staff
- students(curriculum aspects of energy management or promotion of renewable energies)
- implementation of energy plans

Measuring and comparing energy **performance**

Energy performance indicators are essential for effective energy management in any building because they can be used to:

- measure energy consumption over a period of time to determine whether performance is improving, staying the same or deteriorating,
- evaluate energy performance in comparison with other users and with standard values so that relative efficiency can be established, and
- assess the prospective benefits of energy efficiency measures and new energy technologies and monitor their successful implementation and operation.

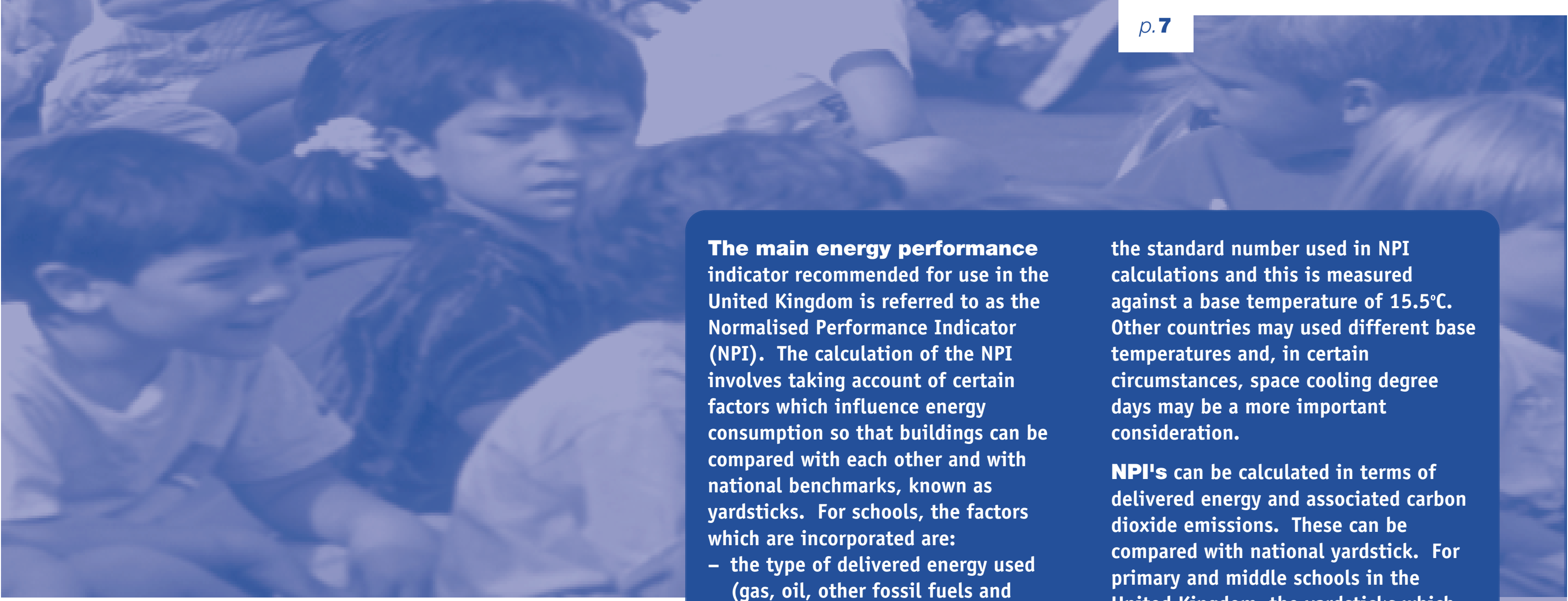
There are many different types of energy performance indicator and they are measured in different ways in different countries. National guidelines are often available for specifying recommended methods of calculation, with adjustment procedures and standard values of performance for comparative purposes.

Fundamentally, energy performance indicators for schools represent a given aspect of energy use per unit space within the school per unit time. Typically, energy consumption is measured in units of kilowatt-hours (kWh). The space within the school either consists of its floor area, in units of squared metres (m^2), or its volume, in cubic metres (m^3). The actual specification of these dimensions (gross or net, external or internal, total or heated) is extremely important since misunderstandings lead to significant errors in the comparison of indicators. The period of time referred to in the indicator is usually one year, although some indicators are based on the period of occupancy or use of the school.

There are a number of important variants of energy performance indicators which are distinguished by the aspect of energy use that they represent. For indicators which relate to energy consumption, in particular, there is a distinction between primary energy, which is a measure of the energy available in natural resources, and delivered energy, which equals the energy provided by fuels and electricity purchased for use in the school. Because of basic differences in the nature of different forms of delivered energy, it is sometimes divided into fossil fuels (coal, natural gas, oil, etc.) and electricity. Other types of energy performance indicator refer to associated carbon dioxide emissions, and financial costs, in local currencies.

Each one of these indicators provides valuable information on different aspects of energy performance. Primary energy indicators refer to the depletion of finite energy resources. Indicators measured in terms of delivered energy demonstrate relative energy efficiency. Indicators based on carbon dioxide emissions measure environmental impact through global warming. Financial indicators provide a guide to cost-effectiveness.

Ideally, all these different types of indicator should be determined and quoted when the energy performance of a school is being evaluated. This is particularly relevant for demonstrating savings derived from the implementation of energy efficiency measures and new energy technologies. No single indicator can represent every type of savings



which can be achieved. For example, it is possible to reduce costs by switching between different fuels without actually saving energy. Furthermore, the use of renewable energy will decrease the demand for primary energy and, subsequently, associated carbon dioxide emissions but may not affect delivered energy consumption and costs in the same way. Hence, the full significance of savings can only be established by quoting all energy performance indicators.

Good data are necessary for the calculation of meaningful energy performance indicators. Obviously, reliable measurements of school floor area or volume are essential. Time periods must also be specified carefully. Access to meaningful fuel and electricity records is vital. These must consist of actual readings which represent energy consumption over relevant periods of time. If savings are being calculated, then accurate records are needed before and after the energy efficiency measure or new energy technology has been installed. It is especially important to obtain relevant records for periods of normal operation and typical school use.

Many factors influence the energy performance of schools. These have to be taken into account so that indicators can be compared on a meaningful basis. This is particularly the case when comparing indicators with national or regional standard values of performance, or benchmarks. Numerous methods of adjustment and types of benchmark are used in different countries across the European Union. An example of the approach adopted in the United Kingdom is presented in the separate box above.

The main energy performance indicator recommended for use in the United Kingdom is referred to as the Normalised Performance Indicator (NPI). The calculation of the NPI involves taking account of certain factors which influence energy consumption so that buildings can be compared with each other and with national benchmarks, known as yardsticks. For schools, the factors which are incorporated are:

- the type of delivered energy used (gas, oil, other fossil fuels and electricity),
- the breakdown between space heating and other energy use,
- the regional weather represented by degree days,
- the exposure of the building (sheltered, normal or exposed),
- the type of construction of the building (lightweight, normal or other),
- the occupancy of the building, and
- the heated floor area of the building.

In the context of space heating, degree days are equal to the product of the number of days on which the outside temperature falls below a given base temperature and the difference between these temperatures. In the United Kingdom, 2 462 degree days is the standard number used in NPI calculations and this is measured against a base temperature of 15.5°C. Other countries may used different base temperatures and, in certain circumstances, space cooling degree days may be a more important consideration.

NPI's can be calculated in terms of delivered energy and associated carbon dioxide emissions. These can be compared with national yardstick. For primary and middle schools in the United Kingdom, the yardsticks which represent medium performance are:

fossil fuels	*137 – 189 kWh/m^2/year*
electricity	*20 – 27 kWh/m^2/year*
carbon dioxide	*41 – 57 kg CO_2/ m^2/year*

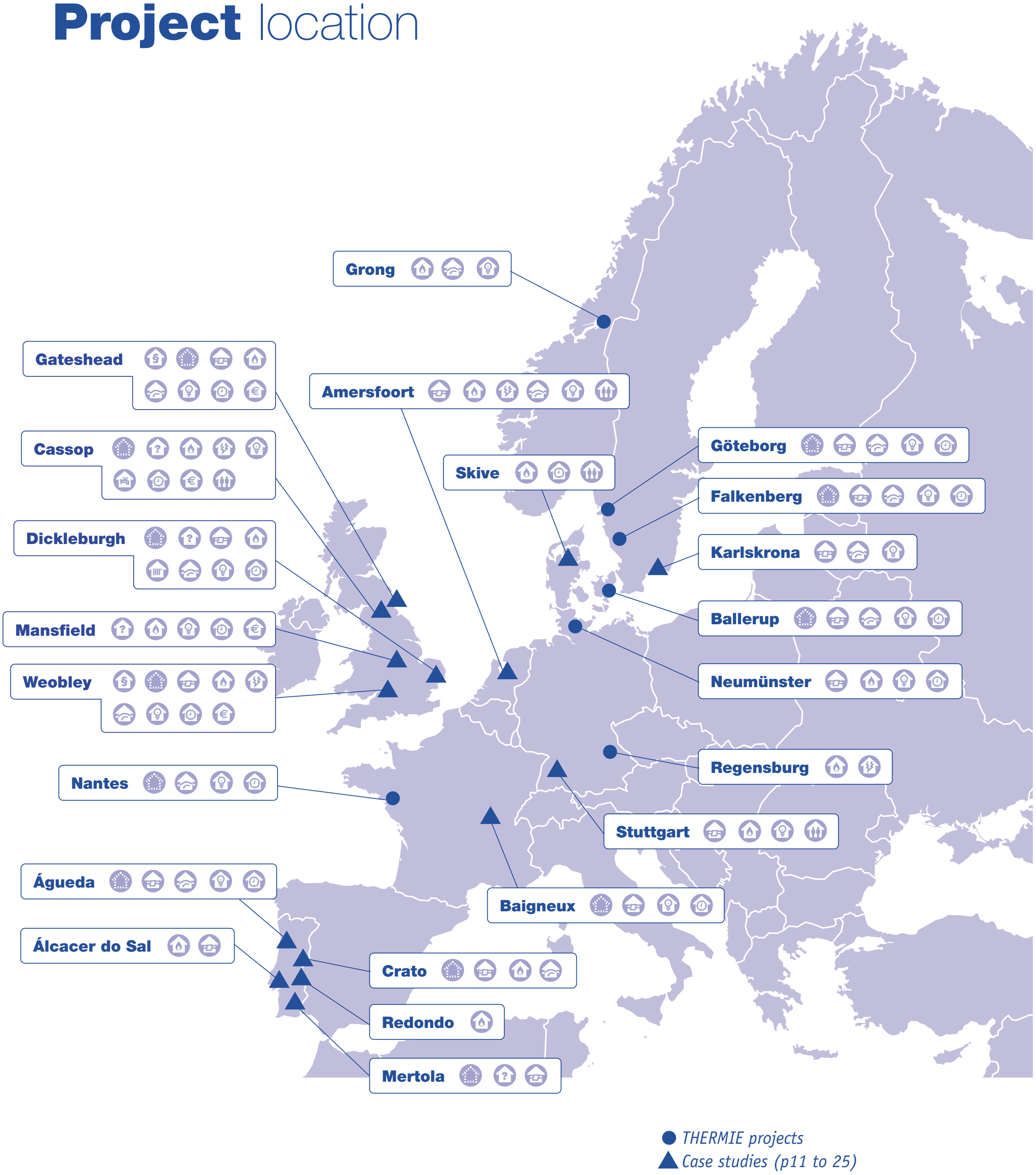
Schools which have NPI's greater than these yardstick have poor performance which could be improved considerably by simple energy efficiency measures. The majority of schools are likely to fall within the range of these yardsticks. However, all schools, regardless of their NPI's , would benefit from energy efficiency measures and new energy technologies.

Source: "Building Energy Efficiency in Schools: A Guide to a Whole School Approach" BRESCU, Building Research Establishment, Watford, United Kingdom, 1996.

It is important to realise that energy performance indicators are not the same as recommended or mandatory standards which are applied when designing and commissioning new, refurbished or renovated schools. Such standards usually consist of specific measurements representing various aspects of the internal environment of the school. This might include the minimum temperature in winter and the maximum temperature in summer (thermal comfort), minimum levels of illumination (visual comfort), and minimum rates of air changes (air quality).

Such measurements are important, however, because they provide a means of assessing the internal environment of the school. This determines whether the school provides a good working, teaching and learning environment of its occupants. Ideally, such information should be incorporated into the further development of energy performance indicators. In the future, the measurement of occupant comfort could be combined with the primary energy consumption or associated carbon dioxide emissions of a school, so that a single indicator of sustainability could be derived and applied in practice.

Project location



Demonstration projects

A number of the projects have been co-financed by the THERMIE programme for the development of energy efficient technologies in schools. A brief summary of the most prominent projects is presented below.

Regensburg *[DE] TEN/38/94/DE*

The project is a study of the local economic impact of energy investments. It demonstrated that these investments had led to a growth in regional energy production, while also having a favourable impact on employment particularly through the secondary effects of reduced energy costs. One part of this study deals with schools: the city of Schönwald carried out an architectural competition in order to design a new school. The proposition selected - in close co-operation with the ZREU, a cross border OPET network for Bavaria and Austria – was then analysed in terms of energy optimisation and eventual modifications to the original plan. The project "Energy Optimisation of Plans for a School Building" took particular account of the building's function as a school. A number of factors have an impact on the total energy efficiency, including the design and creation of spaces, the division and orientation of rooms in the building or the materials utilised. However, it was agreed that any potential modifications to the initial plans were only justified if they did not involve any excessive increase in investment.

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Nantes *[FR] RE 79/ 1997*

As part of a project called BEST 2000 specially designed to optimise energetic behaviour in intermittently occupied buildings, a new school, Lycée des Herbiers, with a floor area of 6 500 m² is to be built in the Vendée department. For all four buildings to be constructed, rationalisation, solar gains and daylighting, no mechanical air conditioning, performance targeting and advanced building control should lead to :

- 50 % energy savings,
- less than a 10% increase in maintenance costs in comparison with a conventional building,
- enhanced users' comfort.

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MEDUCA *BU/0100696*

MEDUCA **(Model EDUCAtional buildings for Integrated Energy Efficiency Design)** is a THERMIE Integrated Quality Demonstration Project which aims to create educational buildings that will stand out as exemplary models of optimised integrated energy efficient design for new or refurbished schools.

Ballerup *[DK]*

The project involved refurbishing a school, with a floor area of 12 000 m² and built in the 1970's, with improved insulation, low energy windows, fan-assisted natural ventilation with pre-heating of air in earth ducts and solar wall collectors, passive solar heating, an advanced control system and energy efficient lighting. It was completed in the summer 1998 and two parts of the overall school building complex, with a floor area of 1 700 m², are now renovated. A qualitative evaluation of the air quality revealed a significant improvement. First monitoring results show a 45% reduction in space heating energy consumption.

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Grong *[NO]*

A school complex from the 1960's had a new building, with a floor area of 1 000 m², added and designed to use solar energy for space heating and pre-heating ventilation, optimised daylight and ventilation with heat recovery based on natural driving forces with fan assistance. The construction was completed in summer 1998.

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Göteborg *[SE]*

Refurbishment of a 1960's school with a floor area of 2 350 m² was planned using an optimised envelope, low energy windows, heat recovery ventilation, passive solar heating and cooling, advanced control system, optimised daylight and energy efficient lighting. The first year in operation was dedicated to optimise the operation of the heating and ventilation system.

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Falkenberg *[SE]*

This project based on a school, with a floor area of 9 350 m², built at the end of the 1960's was planned using low energy windows, heat recovery ventilation,

hybrid ventilation, passive solar heating and cooling, an advanced control system, optimised daylight and energy efficient lighting.

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Neumünster *[DE]*

This project took place in a school complex of 5 buildings of different ages, from 1906 to 1980, and a total floor area of 5 275 m². The project consisted of installing low energy windows and additional heat protection, advanced control systems, building energy management system, efficient lighting, solar hot water for the showers in the sport hall and changing energy supply from natural gas to district heating. The monitoring has been ongoing since October 1998.

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Photo: INETTI

Sustainable energy technologies for schools: Case studies

The fifteen case studies presented here are intended as a practical illustration of the innovative energy solutions that were adopted in new school building or retrofitting projects in Denmark, France, Germany, the Netherlands, Portugal, Sweden and the United Kingdom.

Águeda *[Portugal]*
Escola secundária de Valongo do Vouga

Daylighting optimisation and passive solar design

Valongo do Vouga is located in the northern part of Portugal and has a temperate climate with mild winters and moderate summers (1 496 degree days). The school is elongated along an east/west axis. It is a two storey building consisting of 18 classrooms, several laboratories, a library, a kitchen and a canteen. Corridors and service areas are located on the north side. The classrooms are on both floors and occupy the whole of the south-facing elevation which has 224 m² of windows fitted with double glazing. This makes it possible to achieve significant direct solar gains in winter (52%). During the hottest months of the year, the classrooms are protected against excessive heat by concrete slats fitted onto an independent frame that is fitted 50-60 cm away from the façade. The north-facing side of the school has only 120 m² of double glazed windows to provide daylighting and ventilation. The glazed area to floor area ratio is 20%.

The windows in the classrooms are made of two parts and are fitted on the inside with lightweight slats that act as light reflectors preventing direct solar radiation. Most of the windows on the northern and southern aspects as well as the classroom doors are fitted with vents that provide efficient cross-ventilation. Double casing walls insulated with expanded polystyrene foam are used and any thermal bridges have been carefully treated. One of the most significant features of this building is daylight optimisation. This is achieved by means of reflectors, lightducts and skylights that provide lighting in the darker parts of the classrooms. Energy efficient light fittings are used and an energy management system has been installed.

Águeda City Council, which is legally responsible for work supervision and project completion, defined the specifications in collaboration with the Regional Board of the Ministry of Education in charge of the Central Region. This collaboration was detailed in a co-operation protocol between the City Council and the Ministry stipulating that the City Council was to provide a large part of the funding. A team from the Energy Management Laboratory of the Electro-Technical Engineering Department of the Coimbra Faculty of Sciences and Technology also participated as a consultant in the project.

Contact

António Manuel Portela
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School details

Type of school: Secondary
Floor area: 2 917 m²
Number of students: 505
Year of construction: 1993
Occupancy: 1 995 hours/year

Participants in the project

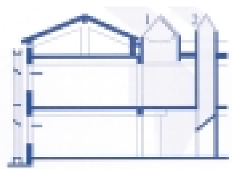
João Mateus (Co-ordinator), Jorge Gouveia and Luís Cunha
Direcção Geral dos Equipamentos Educativos
Direcção Regional de Educação da Região Centro
Câmara Municipal de Águeda
Laboratório de Gestão de Energia da Faculdade Ciências e Tecnologia de Coimbra

Energy performance

The energy performance of the school during winter is 32 kWh/m²/year compared to the benchmark for a conventional school in this area of 64 kWh/m²/year, suggesting a 50% energy saving.

Financial data

Cost of construction including electrical and mechanical installation: €1 600 000.
Energy management and control system: € 196 000.



1. Skylights
2. Light-ducts

Source :
ISBN 972-676-163-8
" Edificios Solares Passivos em Portugal " INETI/DER

Alcácer do Sal *[Portugal]*
Escola primária

School details

Type of school: Primary
Floor area: 1 140 m²
Number of students: 183
Year of construction: 1965
Occupancy:
1 120 hours/year

Participants in the project

Câmara Municipal de Alcácer do Sal
CEEETA – Centro de Estudos de Economia de Energia, Transportes e Ambiente

Energy performance

The total energy savings for the 20 schools in the programme are 223 200 kWh/year with cost savings of € 20 958/year.

Financial data

The total investment cost for the 20 schools was € 24 100, resulting in a gross investment payback time of 1.2 years.

Original use of local energy resources

The cold season in Portugal has only one or two really cold months and summer mainly coincides with school holidays. This is more so in the half of the country nearer to the sea, as is the case of Alcácer do Sal which is situated in the South region, 80 km from Lisbon (1 283 degree days). The Municipality of Alcácer do Sal decided to utilise pinecone scales, which is an abundantly available waste product from the local pine nut industry, for energy purposes in the 20 schools of the municipality. Alcácer do Sal Primary School Nº1 is the biggest one.

The school was provided with 12 pinecone scale-fired heaters. In Portugal, these heaters are commonly called "salamanders" because they are made of iron coated with green enamel. They are specially designed to be automatically fed with pinecone scales. Each 10 kW heater consists of a silo with 10-15 hours storage capacity, a feed system by gravity, a pre-furnace and an air/air heat exchanger. A "salamander heater" was installed in each classroom as a replacement for electric radiators. The average energy needs for each classroom are 9 500 kWh/year.

The school has 4 buildings surrounded by a large playground. Two of the buildings consist of classrooms and the other two are for administrative services and the canteen. The classrooms have an average floor area of 45 m². They face south-east and are provided with large windows. The school has a masonry construction, typical of the type of buildings adopted by the public administration between the 1940's and 1960's. They are spread all over the country and the construction characteristics are identical regardless of the region where they are located.

The complete improvement programme for the 20 primary schools in Alcácer do Sal consisted of installing 49 salamander heaters, fitting thermal insulation to roofs, doors and windows, and removing existing electric radiators. The net calorific value of the pinecone scales is 4 kWh/kg and the annual consumption by all 20 schools in the programme is 200 tonnes. The annual consumption for this individual school is 49 tonnes. This is a good example of how to use a local energy resource economically while protecting the environment.

Contact

Engineer Pedro Oliveira
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Photo: Jan van Ijken

Amersfoort Nieuwland *[Netherlands]*
Basisschool De Wonderboom

Solar panels for generating electricity

From 1995 to 1997, three primary schools were built in the Nieuwland development of Amersfoort in co-operation with REMU, the national energy company. The main objective was to implement energy-saving measures and develop the use of sustainable energy. De Wonderboom primary school is part of the three energy-saving school buildings. 196 solar photovoltaic (PV) panels have been fitted on the roof of the school and positioned so as to collect the maximum of sunlight. Each classroom has 24 panels arranged in 6 rows of 4 panels each connected to primary and secondary electricity collection units. The PV panels of each pair of classrooms are connected to an inverter which converts the voltage and feeds electricity into REMU's low-voltage network. The PV system is the property of REMU, as part of an agreement with Amersfoort City Council. Windows have been fitted in the south-facing roofs in between the PV panels, so sunlight shines directly into the building. In this way, passive solar energy is utilised. Windows have also been fitted on the north side of the roof to allow more daylight into the classrooms. The school is equipped with a display which shows how much energy is consumed and generated, compared with the target performance for the school. This enables both staff and students to appreciate the efficient energy usage of the school.

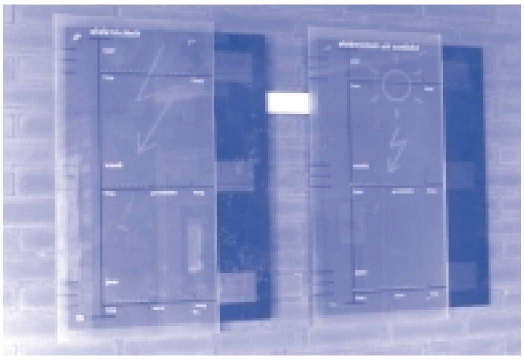

Photo: Jan van Ijken

The school has high-efficiency glazing which provides improved thermal insulation in the rooms where it is fitted. The insulation value of high-efficiency glass is twice that of ordinary double glazing. There is also extra insulation that ensures that walls, floors and roofs have a higher thermal resistance. Three high-efficiency boilers have been installed, one per heating group. By recovering heat from the flue gases, these boilers achieve efficiencies between 90 and 95% compared with only 75 to 80% for a conventional central heating boiler. Emissions of harmful pollutants, such as carbon dioxide and oxides of nitrogen, are considerably reduced due to lower gas consumption. Heat is recovered from stale ventilation air as it is extracted. The air is extracted and blown out through an aluminium cartridge which absorbs the heat. Fresh outside air is drawn in through another cartridge. After 70 seconds a swivel valve is turned so that the flows of air through the cartridge are reversed. The stored heat is transferred to the fresh air. With this system some 85% of the heat in the stale ventilation air can be recovered. High-frequency lighting in the school building ensures that the same amount of light is produced with about 20% less energy. This saving can be achieved because the losses in high frequency ballast are low compared with conventional ballast.

Contact

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School details

Type of school: Primary
Floor area: 1 070 m²
Number of students: 470
Year of construction: 1996
Occupancy: 1 400 hours/year

Participants in the project

Sports, Recreation and Education Service, Amersfoort City Council
Bakker & Poolen Architect
REMU Utrecht (Owner of the photovoltaic system)
NOVEM (Provider of the subsidy for the photovoltaic system)

Energy performance

The annual consumption of gas for heating purposes amounts to 76 kWh/m²/year. The PV installation reduces electricity consumption by some 8 000 kWh/year.

Financial data

Sports, Recreation and Education Service of Amersfoort City Council, the owner of the school, granted REMU a right of superfices. REMU installed the solar panels and receives the electricity generated. Subsidies were granted by NOVEM for the installation of the solar energy systems.
NOVEM subsidy (60%): € 10 840
REMU integration PV: € 6 800
REMU PV: € 76 370

Photo: Jan van Ijken

Photo: Jean Bouillot

School details

Type of school: Nursery and Primary
Floor area: 505 m²
Number of students: 100
Year of construction: 1993
Occupancy: 1 480 hours/year

Participants in the project

Sivom (Intermunicipal Organisation) of Baigneux les Juifs
SARL F. Brandon et associés
Jean Bouillot architect

Energy performance

The space heating energy consumption for this school is 50 kWh/m²/year.

Financial data

The cost of installing the energy technologies in this school was € 148 per m² of heated area. The payback period is between 11 and 13 years.

Baigneux-les-Juifs *[France]*
Groupe scolaire Les Capucines

Energy efficient building design

Due to the harshness of local climate conditions (3 100 degree days), the objective of the architects was to protect the classrooms against cold and position them so as to receive the maximum of solar heat and light. This is why intermittently occupied rooms or closed rooms were placed at the north and north-east side. An atrium hall was added to this first heat buffer zone. The roof slope is 15° on average, an incline that minimises wind pressure and prevents the snow from falling off the roof in winter, thus creating a thermal blanket.

Classrooms are south-west facing with a stepped façade including a double row of windows. The top windows set back from the lower level to allow maximum solar radiation into the back of the classroom. Indirect lighting has been extensively used to minimise risk of dazzle. Sun breakers have been installed to this effect and the top windows have been placed on a small terrace covered with a reflective flooring which directs the sunlight toward the ceiling.

The atrium forms a longitudinal inside alley leading to four classrooms: the south-west facing nursery room and the three primary rooms. These are positioned in line with a slight indent so as to accommodate a south-east facing French window which catches the morning light while facilitating the progressive and cumulative lay-out of the rooms. Solar radiation enters the atrium through a glass roof. In order to filter and subdue excessive sunlight coming through at the beginning and at the end of the school year and to limit night losses in winter, an inside canvas awning has been provided. Additionally, the walls of the atrium are light-coloured. Despite all

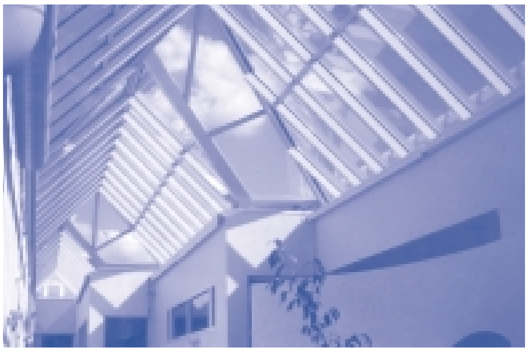

Photo: Jean Bouillot

these provisions, and due to the weakness of canvas screens, the atrium is considered to be too hot and much too bright when the sun is at its zenith towards the end of the school year in June. Hence, it may be necessary to fit a physical filter on the outside of the glazing of the atrium.

The building envelope is made of rendered blockwork walls. Interior walls are 16 cm thick concrete shuttered walls and offer good thermal inertia for the whole building. The building floor is also massive and inert so that it has a high thermal inertia to assist space heating and cooling depending of the time of the year. The intermittent and seasonal occupation of the building, the differences in students' ages and the diversity of the activities performed make managing the space heating system relatively complex. This consists of oil heating with underfloor heat distribution in the nursery room and the rest room and through hot water radiators in the classrooms. Six zones with different temperatures have been identified. The management of the system for space heating incorporates programmes for each zone with suitable occupation scenarios.

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Cassop *[United Kingdom]*
Primary school

Grid-connected wind turbine

The school is a brick built Victorian building which has been substantially re-designed inside to give a smaller number of large semi-open plan classrooms and shared practical areas. Ceilings have been lowered throughout the school as an energy saving measure. The school is lit by energy efficient lights as a result of an initiative by the Education Department of Durham County Council. At the moment the school is heated by an oil boiler. Alternative energy sources for space heating are being investigated. The school has a national reputation for environmental activities especially in terms of educational activities related to renewable energy technologies and promoting recycling. An energy team, which includes the head teacher, caretaker and a group of students, examines the possibilities for saving energy and water.

Cassop School was identified as an ideal situation with high wind energy potential as part of Durham County Council Renewable Energy Strategy. The wind turbine chosen, which is the first grid-connected wind turbine generator to be installed at a school on mainland United Kingdom, is an Atlantic Orient Corporation 15/50 kW machine, producing 50 kW at a wind speed of 12 metres per second. The wind turbine started operation on May 1999. It is estimated that it will produce 100 000 kWh/year in an average wind speed of 6.7 metres per second for this location.

The school's average electricity consumption of 40 000 kWh/year will be supplied by the wind turbine. Any excess electricity produced will be sold to Northern Electric and Gas for use in their distribution system. The income generated will be put into a fund to pay for maintenance of the wind turbine. It is expected that, at the current rate of consumption by the school and the rate paid by Northern Electric and Gas for the excess electricity, the wind turbine will pay for itself within its lifetime. However, with increased energy efficiency at the school and possible higher levels of return on such "green energy", the payback time could be considerably reduced for similar future projects. The wind turbine also serves as an educational example for the County's school students. An interactive display within the school demonstrates the way in which the turbine supplies electricity and relates this to how the school uses energy. This has already aroused sufficient interest to result in many wind-related projects in science, art and language.

Contact

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School details

Type of school: Primary
Floor area: 1 223 m²
Number of students: 87
Year of construction: 1912
Occupancy: 1 480 hours/year

Participants in the project

Durham County Council
Northern Electric and Gas
Winsund (Hugh Jennings) Ltd
National Engineering Laboratory
Alpha Communications (Display Panel)

Energy performance

Reductions in associated carbon dioxide emissions for the school amount to 25 tonnes per year. This can be compared with an average benchmark of 60 tonnes per year for a similar type of school resulting in savings of 41%.

Financial data

The cost of installation was € 182 540. € 34 650 was contributed by Northern Electric and Gas, which also provided € 3 175 of the € 15 875 cost of the interactive display panel. The rest was funded by Durham County Council.

Photo: Cassop primary school

Photo: INETTI

Crato *[Portugal]*
Escola secundária

School details

Type of school: Secondary
Floor area: 2 950 m²
Number of students: 348
Year of construction: 1988
Occupancy:
1 995 hours/year

Participants in the project

Luís Cunha; Rosa Bela Costa (Architect)
Ministério da Educação : Direcção-Geral das Construções Escolares
Direcção Regional de Educação do Alentejo

Energy performance

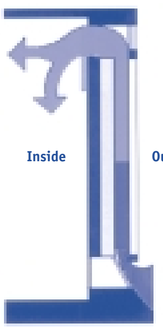
The energy performance of the school in winter is 33 kWh/m²/year compared with a benchmark of 67 kWh/m²/year for conventional school in this region. This implies an energy saving of 51%.

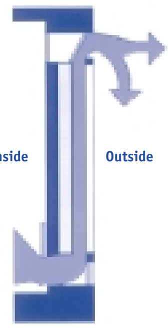
Financial data

The total investment cost was € 603 500.

Air-based solar heating and cooling

Winter weather conditions in this region are not harsh (1 683 degree days)but in summer it is extremely hot although this mainly coincides with the school holidays. The school was designed to be compatible with the need for solar protection in summer and the accumulation of solar gains during winter. The classrooms are south-facing and provided with large glazed areas (995 m²) to achieve 40% solar gains. The ratio between the glazed area and floor area is 27%. The building has two storeys and surrounds two playgrounds. Two ponds with small fountains cool the atmosphere by means of evaporation during the hottest periods of the year. However, the playgrounds are also designed to absorb solar radiation, in order to avoid excessively moist atmospheric conditions in winter.





40 m² of air solar collectors are used in winter to preheat fresh intake air blown through natural ventilation into the classrooms. In summer, they force stale air out of the classrooms through cross-ventilation. These collectors, integrated into the south-facing elevation, act as a heat absorber. They are made of a layer of glass with a heat absorbing surface but no storage capacity. During winter, the air from the outside is heated and blown into the room, and air renewal is achieved without any losses. In summer, the temperature differential provides for air extraction from the room. The vents are operated manually by the users. The system performance was assessed in November 1994. The heated air reaches temperatures that exceed 40° C, whereas the temperature of the absorbing surface is about 70° C.

The building is well insulated and has a high thermal inertia. The walls have double masonry casings, each 15 cm thick insulated with 7 cm of black agglomerated cork. The roof is covered with tiles, the attic space is well ventilated and the floor is insulated with a 10 cm layer of lightweight concrete and a 7 cm layer of black agglomerated cork.

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Source :
ISBN 972-676-163-8
" Edificios Solares Passivos em Portugal " INETI/DER

Photo: Norfolk County Council

Dickleburgh *[United Kingdom]* Primary school

Low energy design and ground water heat pumps

The school was built incorporating passive solar principles and a very high standard of thermal insulation in the external walls and roof (U-value of 0.25 W/m² °C). Cavity walls insulated with 5 cm of polystyrene are used. The roof contains 16 cm of mineral fibre between the ceiling joists.

The school was built in the form of a triangle, with the narrow north-facing elevation consisting of the kitchen stores and the plant room acting as a buffer for the shared accommodation at the centre of the school. The classrooms are south-facing with lean-to greenhouses, or solaria, added to maximise solar heat gains and reduce heat losses in winter. Even on sunless winter days the temperature within the solaria remains 3 - 5°C above the external ambient temperature. This is maintained at 15 - 20°C during bright sunshine even when the outside air temperature remains close to freezing. To minimise overheating in summer, the greenhouses are provided with opening roofs and side vents and the fixed glass in the roof section is treated with solar reflective film.

The average glazing to wall ratio is 25%, comprising 40% single glazing on the southern aspect reducing to only 10% on the northern aspect where double glazing is fitted. Thermal shutters are provided for the large south facing windows which can be closed overnight during the winter months to retain heat. The school also utilises two heat recovery ventilation systems which extract air from the central core of rooms, such as circulation spaces and toilets, and feed pre-heated air to the activities hall. These combined energy efficiency measures reduced the maximum space heating demand of the building from 75 kW for a conventionally- built school to just 35 kW.

Electrically-driven heat pumps, utilising ground water as the heat source, are used to provide for space heating. Geological tests indicated that an extensive supply of ground water at a temperature of 10 - 12°C is available at the school site throughout the year. As the school is in a rural area, there is no gas supply and the heat pumps, although run by electricity, enable this form of energy to be used more efficiently for space heating purposes. The heat extracted from the ground water is upgraded to 45°C by the heat pumps and is used to heat the school via polypropylene underfloor heating coils in the classrooms and activities hall and natural/fan-assisted convectors elsewhere. The total electrical rating is only 11 kW including circulation pumps. The heat pumps operate with a coefficient of performance of approximately 3.5 which means that 3.5 kW of useful heat are produced for every 1 kW of electrical input.

The high standard of thermal insulation reduces space heating requirements and enables the school to be heated overnight so that cheaper "off-peak" electricity can be used. This allows the heat pumps to run at night for 80% of the time. Domestic hot water is provided by means of off-peak electricity with on-peak top-up as required during the day. This is supplemented by 35 m² of solar panels incorporated into the sloping south face of the roof. The school is linked to Norfolk County Council's Remote Energy Management System and can be effectively monitored on a day-to-day basis.

Photo: Norfolk County Council

Contact

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School details

Type of school: Primary
Floor area: 520 m²
Number of students: 108
Year of construction: 1985
Occupancy: 1 710 hours/year

Participants in the project

Norfolk County Council

Energy performance

An energy performance of 80kWh/m²/year has been calculated for the school and this can be compared with a benchmark of 180kWh/m²/year which would be representative for this type of school. This implies energy savings of 56%.

Financial data

The capital cost of the energy efficiency measures and the new energy technology in this school was € 9 450 in 1984 prices.

Photo: Gateshead Metropolitan Borough Council

Gateshead *[United Kingdom]*
Joseph Swan comprehensive school

School details

Type of school:
Junior High

Floor area:
Original school - 12 800 m², new extension 7 600 m²

Number of students: 1 260

Year of construction:
Original school 1963, new extension 1999

Occupancy:
2 565 hours/year

Participants in the project

Gateshead Metropolitan Borough Council
Ove Arup and Partners

Energy performance

An energy performance of 108 kWh/m²/year of natural gas for space and water heating has been anticipated compared with an average benchmark of 177 kWh/m²/year for a similar type of school. This is equivalent to a 40% saving in energy consumption.

Financial data

The contract sum was € 9 794 000 which included both alteration and new build works. Overall, the costs were comparable to other similar school projects carried out by the Council.

Photo: Gateshead Metropolitan Borough Council

Solar gain as a contribution to space heating

The project consisted of a major extension to the existing Junior High School. The new extension features a glazed atrium which links all teaching spaces. This design allows the building to utilise solar gain as a contribution to space heating requirements. The building is constructed using the CLASP system which guarantees a good thermal performance through the use of mineral wool insulation in external walls and a "warm" roof construction.

A combination of both mechanical ventilation (with heat recovery) and natural ventilation strategies are utilised depending upon the space requirements to satisfy fresh air supply and to provide ventilation in summer. Opening windows are fitted throughout the school where possible. Ventilation stacks are used in all new teaching blocks and provide a degree of cross-ventilation. The stacks rise and exhaust stale air through high level louvered outlets. The atrium is ventilated via opening windows at low level and automatic louvered vents at high level.

The original school is heated by solid fuel. The new extension is heated by a series of high efficiency gas-fired boilers of approximately 900 kW total output. The heating system operates at a low pressure with a design flow water temperature of 60°C and a return water temperature of 40°C in order to reduce flow rates and pipe sizes and also to maximise the efficiency of the boilers. The building has been zoned according to anticipated usage, each zone being compensated according to internal and external air temperatures.

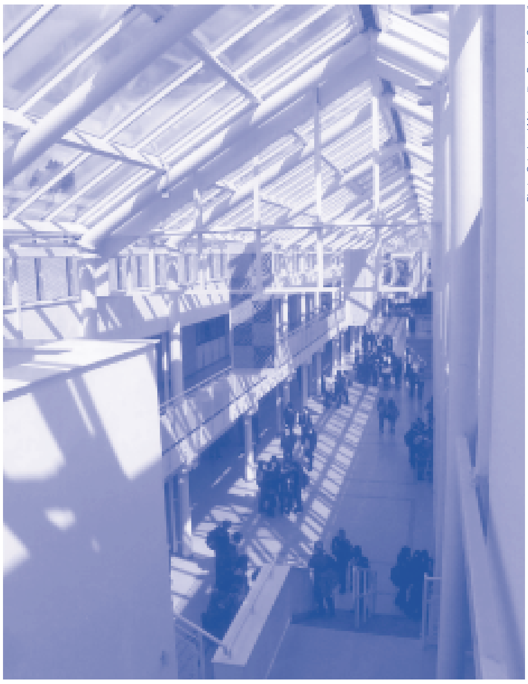

Photo: Gateshead Metropolitan Borough Council

Contact

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Karlskrona *[Sweden]*
Jändelskolan

Novel design of ventilation system

The Jändel school was built in 1960 in the form of single-storey buildings with flat roofs. During 1994-1995, a major retrofitting scheme was undertaken. The school has now a pitched roof reducing the risk of moisture damage and providing space for fan rooms and ventilation ducts. Both lighting and ventilation systems have been designed for very high energy efficiency. New windows with very low U-values have been installed. This has eliminated cold downdraughts from the windows, so that radiators are no longer needed below them. Instead any extra heat that is needed is supplied via the ventilation air. In order to prevent excessive temperatures in classrooms, the windows have protective solar layer.

The heating system was integrated into the ventilation system. Any additional heat needed is supplied to the air in the building by the ventilation air. The ventilation system consists of four air treatment units, installed in the roof space. The main distribution ducts are large enough to allow entry for maintenance and cleaning. Heating coils are placed in the main distribution duct. The fans are of an axial type with variable frequency speed control. The heat exchanger is a double flat-plate heat exchanger with bypass dampers for capacity control. It recovers at least 85% of the energy (95% at night and during the weekends). There are no air filters in the system. Instead insect netting is fitted over the supply air intakes. The school is located in a rural area, with little air pollution. However some of the larger dust particles settle out in the distribution ducts, and vacuum cleaners can be used for cleaning each air-handling unit and ductwork.

The air is supplied through two supply air vents mounted in the wall, blowing the air downwards at high speed. Although air velocity at the supply vents is high, integral ejectors for the room air combined with the fact that the high air velocities are limited to a space of only a few centimetres above the floor, mean that no draught problems are experienced. The air is distributed across the floor and then rises to be removed through exhaust air grills in the ceiling.

Measurements of both the indoor climate and energy use were made during January 1995. The results, complemented by a questionnaire that was carried out at the same time, show that the indoor climate is very good and that the overall energy efficiency is good.

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School details

Type of school: Secondary
Heated area: 4 415 m²
Number of students: 419
Year of construction: 1960
Occupancy:
2 550 hours/year

Participants in the project

Municipality of Karlskrona with the school administration and technical services
NUTEK
Built by contractors and workers from the Unemployment Office in Karlskrona

Energy performance

The energy required for space heating has been reduced from 210 kWh/m²/year to about 94 kWh/m²/year, resulting in savings of 55%. Electricity for building systems has also decreased by about 20% despite the increased number of computers used. In addition to the energy cost reduction, retrofitting works provided the Municipality with a new school for at least 30 years with halved heating costs and much better comfort for pupils and employees.

Financial data

The whole investment for the retrofitting is about € 2 000 000. The payback period for extra costs for investments in lighting systems is about 4 years. The space heat- and ventilation-system was actually cheaper than a traditional system. The energy costs have been reduced by € 40 000.

Mansfield *[United Kingdom]*
Beech Hill special school

School details

Type of school: Primary
Floor area: 1 490 m² (126 m² for mobile classrooms)
Number of students: 70
Year of construction: 1960
Occupancy: 1 300 hours/year

Participants in the project

Nottinghamshire County Council
Energy Saving Trust
East Midland Electricity

Energy performance

Potential electricity savings due to lighting improvements are estimated to be 7 535 kWh per year, which is equivalent to a reduction of 3% in comparison with the typical consumption of a similar type of school. This results in predicted savings in associated carbon dioxide emissions of 5 tonnes per year, or a 6% reduction compared to typical emissions from a similar school.

Financial data

Cost savings total about € 795 each year for lighting purposes. Additional savings in electricity consumption, associated carbon dioxide emissions and costs are expected from the space heating control equipment. The cost of the space heating control system was € 635.

Low-cost electricity savings in heating and lighting

Many schools throughout the County of Nottinghamshire have temporary "Portakabin" accommodation, often referred to as mobiles, for use as classrooms. Although intended as a short-term solution to problems of space, it is not unusual for such mobiles to be used over an unexpectedly long period of time. Due to the originally intended purposes of such accommodation, these mobiles are usually heated by on-peak electric fan heaters. These are relatively cheap to install and simple to control, but are comparatively expensive to operate. Hence, measures to reduce the electricity consumption of these heaters are attractive options. As part of a programme of energy efficiency improvements in schools across the County of Nottinghamshire, simple, relatively low-cost measures were selected and implemented in relevant situations. Beech Hill special school provides an example of the measures applied in this programme of work.

At Beech Hill special school, a control system for the electric fan heaters in these temporary classrooms was installed in 1997. It consists of an optimum start controller with a room sensor plus a movement detector. The optimum start has ensured the space heating is brought on when required, the room sensor maintains the room at the correct temperature and the movement detector sets back the heater when the room is empty with a temperature reduction of 5°C. This effective control of space heating has reduced electricity consumption in these temporary buildings

Additional electricity savings have been achieved as a result of a County-wide scheme to replace all 60 W and 100 W tungsten filament light bulbs in classrooms, offices and corridors with more efficient fluorescent lights. The main purpose of this scheme was to improve lighting conditions and save energy. Work on replacing less energy efficient light bulbs was carried out at Beech Hill special school in 1998. In total 124 bulbs, each rated at 100 W, were replaced. The types of energy efficient lighting selected in specific areas depended on the actual use of the space. 16 W compact fluorescent lights were fitted in the corridors and slim-line 58 W fluorescent tubes were installed in the classrooms and offices. This demonstrates the importance of targeting appropriate, low-cost energy efficiency measures.

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Photo: INETTI

Mértola *[Portugal]*
Centro infantil

Design integrating thermal considerations

The Mértola nursery school was built incorporating good thermal design utilising solar energy to a maximum. Locally, the winter is mild (1 356 degree days) and the summer is extremely hot, although this season partly coincides with school holidays. The school was built on a gently sloping site, which made it possible to partly bury the northern elevation. Internal space is distributed between two main areas. The biggest area is well positioned with a south/south-east facing aspect. This face of the building integrates a series of passive solar systems, including Trombe walls in the façade, greenhouses and large windows to capture and store solar energy in winter. The Trombe walls are made of concrete and are fitted with low level and high level vents. The exterior of the wall is painted black and protected by a layer of glass. Ambient air is extracted through the low level vent and passed into the room through the high level vent. At the end of the day and at night, the ventilation system provided by the Trombe wall makes it possible to release the heat stored in the wall during the day.

Photo: INETTI

The school has a floor area of 669 m² and a glazed area of 156 m² giving a glazing to floor area ratio of 23%. The Trombe walls account for roughly 75% of the whole building glazed area and are connected to the rooms with the highest occupancy rate, such as the classrooms and activity rooms. The walls have double casings and the space in between is filled with shale, which is an abundantly available material in the area. The walls in contact with the ground and the roof are insulated with between 4 and 5 cm of expanded polystyrene foam. The south-facing façade has a glazed area of 110 m² fitted with double glazing. Direct solar gains come through the windows and the greenhouses, and indirect gains through the Trombe walls. In summer, most of the windows are provided with solar shading devices. Slats protect the first storey and the protruding first floor acts as solar protection for the ground floor level. In summer, excessive heat is prevented by placing reed mats, as quite a common regional tradition, on skylights instead of insulating curtains. Further shading is provided by trees which were planted as part of this project. Cross-ventilation, incorporated in the project, proved to be a failure due to a mistake in the construction phase.

Contact

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School details

Type of school: Nursery
Floor area: 669 m²
Number of students: 141
Year of construction: 1982
Occupancy: 2 580 hours/year

Participants in the project

Santa Casa da Misericórdia de Mértola – Private Social Solidarity Organisation founded in 1554 (School Owner)
Câmara Municipal de Mértola

Energy performance

The energy performance of the school in winter is18 kWh/m²/year, compared with a benchmark of 61 kWh/m²/year for a conventional school in this region. This indicates energy savings of 70%.

Financial data

Total cost of this project was € 69 000

Source :
ISBN 972-676-163-8
" Edificios Solares Passivos em Portugal " INETI/DER

School details

Type of school: Primary
Floor area: 1 520 m²
Number of students: 190
Year of construction: 1948
Occupancy:
1 120 hours/year

Participants in the project

Câmara Municipal do Redondo
Ministério da Educação

Energy performance

Compared to the previous situation where space heating was provided by electric radiators using 114 550 kWh/year, the new system gives annual energy savings valued at € 1 900.

Financial data:

The total investment cost for the heating system amounted to € 31 517, of which 70% was supported by the Valoren Programme of the European Commission. The gross investment payback time, without financial support, is 5.5 years.

Redondo *[Portugal]*
Escola primária

Efficient and economic use of a local energy resource

Redondo is situated in Alentejo in the southern part of Portugal , 200 km from Lisbon. Winter in this region only has two or three really cold months (1 431 degree days). Redondo is a wine-producing area and each year 510 tonnes of pruned vine twigs are available as a waste product for potential use. The Municipality of Redondo, in order to solve the local school heating conditions, decided to equip it with a centralised space heating system designed to burn vine twig bundles. Vine twigs are collected in the vineyards using a special hay bailing machine and are packed in bundles of 0.5 m diameter and 1 m in length. This activity is supported by the municipality. One hectare of vineyard produces approximately one tonne of vine twigs. Once dried, to a humidity of 15%, the net calorific value of the vine twigs is near 4 kWh/kg, which is equivalent to about 400 litres of fuel oil. The heating system relies on water storage and, therefore, takes up the peak heating during the combustion of the vine twig bundles, thus enhancing its efficiency and autonomy.

The school is of masonry construction, typical of public buildings erected between the 1940's and 1960's. It has 13 classrooms distributed between 3 buildings which are heated by the centralised space heating system. This consists of a 150 kW horizontal hot water boiler with reversed flame, fed with the vine twig bundles or wood and three hot water distribution grids, one for each building. The total energy released is stored in a water tank that can contain up to 5,000 litres. The water tank is connected to the boiler by

means of a four-way valve which keeps the return temperature to the boiler higher than 55°C, which is the dew temperature. Hot water is independently piped to radiators in each building in accordance with the outside temperature and occupancy rate.

Contact

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Photo: JW LUFTFOTO

Skive *[Denmark]*
Højslev Skole

Zone controlling system and solar heating systems

A zone controlling system, which controls the heat supply to all rooms, was fitted to 9 primary schools in the municipality of Skive. One of these, Højslev primary school, was originally heated by an oil-fired system up to 1963, when it was converted to district heating. Prior to installing the zone controlling system, the school heat supply was divided into 9 zones of 800 m² each. Installation took place in 1989. It is now divided into 72 zones ranging from rooms for teaching, teachers' room, halls, toilets, etc.

Due to relatively cold winters (3 350 degree days), the schools in Skive have significant space heating demands. In 1994, the government instructed municipalities to find means of decreasing the demand for energy in the buildings by 25%. The schools in Skive had already made considerable progress with energy efficiency improvements, so an additional solution to zone controlling was necessary. Thus, a proposal involving the installation of a large solar heating system was put forward for Højslev primary school. The result was a solar heating system with an area of 375 m², which could supply approximately 450 kWh per m². The system differs in four different ways from conventional solar heat systems:

Photo: Hans de Lund

- The system was designed to provide space heating, primarily, and water heating, secondarily.

- A part of the installation tested new features involving special reflectors , consisting of bright aluminium plates, mounted on half of the solar collectors. The reflectors were positioned so that, when the sun is higher than 30° above the horizon, sunlight is reflected onto the solar collectors. This construction is intended to capture approximately 20% more energy than a conventional solar heating system.

- When a large solar heat system is installed in a school, which is closed during the summer, problems can arise with excessively high temperatures in the installation. The intention was from the start to try to convince the privately-owned heat district heating utility in the city to buy this amount of heat in the summer. The heat utility agreed to co-operate. The solution was for the school pumps to deliver hot water into the district heating network at a minimum temperature of between 70 and 75°C. Security systems have been installed to ensure that, in case of a system failure, the school is "cut-off" and any risks to the network are avoided. The utility pays a price for the delivered heat from the school which equals half of the price the school has to pay when it buys heat from the utility.

- The circulation pumps are run with variable flow as a function of the required temperature in the school. This gives a high degree of efficiency for the solar heat system and low electricity costs for the pumps.

Contact

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School details

Type of school: Primary
Heated area: 6 721 m²
Number of students: 415
Year of construction: 1902, 1907, 1957, and 1963
Occupancy: 1 600 hours/year

Participants in the project

Municipality of Skive
Danish Energy Agency
Danish Technological Institute
Søby-Højslev Heat Utility
Arcon Solar Heat Inc.

Energy performance

Before zone controlling was installed, the yearly space heating demand was 170 - 175 kWh/m²/year. Afterwards, this decreased to approximately 125 kWh/m²/year. The specific demand for space heating in the school since the installation of the solar heating system in 1994 decreased by 25 %.

Financial data

The investment for the zone controlling system was approximately € 47 000. With an annual saving of approximately 300 000 kWh, the simple pay back time is approximately 3.5 years. The investment for the solar heat system was € 134 000, 30 % being covered by grants from the Danish Energy Agency.

Stuttgart-Plieningen *[Germany]*

Grund und Hauptschule

School details

Type of school: Primary and Secondary

Floor area: 5 420 m²

Number of students: 500

Year of construction: 1930, 1950 and 1970

Occupancy: 1 400 hours/year

Participants in the project

Stuttgart City Environment Protection Department
Fraunhofer Institut für Bauphysik
Institut für Kernenergie und Energiesysteme
Stuttgart City Building Department and specialised consultants
Industrial project partners as well as teachers, parents and students

Energy performance

The space heating requirements of the school have been reduced from between 200 and 220 kWh/m²/year to 58 kWh/m²/year, resulting in an average saving of 72%. The electricity consumption is now 14 kWh/m²/year compared with 11 to 20 kWh/m²/year, indicating an average saving of 10%.

Financial data

There are three sources of financing for the project: The financing of the maintenance and refurbishment measures that would have been necessary anyway were paid by the City of Stuttgart. Each of the industrial partners contributed material, money or consulting/engineering services. The German Ministry for Education, Research and Technology took responsibility for the research component. The total investment costs were about € 3 100 000.

Radical energy efficient refurbishment

This school, which dates from the 1930's, has a facade which was regarded as worth protecting, therefore only internal insulation measures could be considered as appropriate in any refurbishment scheme. A second part of the building dates from the 1950's and a third part was built in the 1970's. The whole building structure suffers from cold bridges due not only to the age of the structure and the materials used but also to connections between different construction elements. The windows of all three buildings had wooden frames that have been damaged. Lighting in the classrooms was poor as there was much dazzling sunlight which meant that shading protection was closed during the whole day and artificial light was used. The heating system was located in the oldest part of the building. Since the installation of the boiler in 1969, no major changes had been undertaken. Before the project, two low pressure boilers with 800 kW were used to heat the school. The boiler had to be switched on and off manually by the caretaker. The caretaker's apartment was also heated by this boiler which meant that parts of the school building were heated even during school holidays.

As part of a major refurbishment of the school, a new condensing boiler with low NOx (oxides of nitrogen) emissions was installed. Energy consumption at peak output can be reduced by 60% compared to the previous boiler as the insulation measures lower the space heating demand of the building considerably. Radiant panels with low water capacities were installed. In order to achieve radiative balance, these panels are placed above the windows. In all parts of the building, the outer walls have been insulated, either on the inside or outside, depending on preservation requirements. In the two older parts of the building, the bottom of the top floor has also been covered with insulation foam. The insulation measures on the top floor have been applied under the roof by teachers and students so that costs have been reduced and awareness on energy matters has been raised. During the installation of all these measures, cold bridges were eliminated whenever possible and as efficiently as possible. Lighting needs in the classroom were reduced by painting the classrooms walls in lighter colours. However, the lighting installations have also been changed. Lamps with electronic ballasts and daylight-dependent lighting controls have been fitted.

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Photo: Pirjo Mailammi

Weobley *[United Kingdom]*
Primary school

Wood fuel as a sustainable alternative to fossil fuels

Photo: Resources Research Unit

The heating system in this new primary school is a demonstration of how wood fuel can be used efficiently and economically as a sustainable alternative to fossil fuels. A 350 kW wood-fired boiler was installed in 1997 and was fully operational during autumn 1998. It operates for about 600 hours per year and provides baseload space heating requirements. As the primary school design heat load is only 115 kW, the rest of the heat is exported to the adjacent high school. Wood chips from woodland thinning operations are supplied by a co-operative of local farmers known as 7Y Machinery Ring. Willow and poplar short rotation coppice will also be used to supply wood chips in the future. All the wood will be grown within a 16 kilometre radius of Weobley.

The building is well-insulated; floor, roof and outside walls are highly insulated. The concrete blockwork of the inside walls is designed to store heat and release it gradually. The building is designed to utilise daylight as well as natural ventilation. By opening high and low level windows, air can be drawn through the classrooms. The high level windows provide excellent lighting. Low energy light fittings are installed. Local building materials which are recycled, natural or non-toxic have been used. This includes the use of local bricks, timber window frames, recycled newspaper insulation, damp proofing produced from reprocessed plastics, recyclable clay roof tiles, aluminium glazing bars, guttering and roof sheeting, rubber and timber flooring and water-based paints. A building energy management system with occupancy detectors in rooms is used to control energy use in the school.

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School details

Type of school:
Primary school with adjacent High school

Floor area:
Primary school – 1 252m², High school – 3 392m²

Number of students:
Primary school - 240, High school - 600

Year of construction:
Primary school - 1997, High school - 1955-1970

Occupancy:
Primary school - 1 368 hours/year, High school - 1 596 hours/year

Participants in the project

European Regional Funding
Ministry of Agriculture, Fisheries and Food
Rural Development Commission
Department of Trade and Industry through the Energy Technology Support Unit
Hereford and Worcester County Council

Energy performance

Estimated reductions of 78 tonnes per year in associated carbon dioxide emissions are expected for the school. This can be compared with an average benchmark of 228 tonnes per year for a similar type of school, resulting in savings of 34%.

Financial data

The funding for modifying the school building with high levels of insulation and other energy saving features was provided from the normal budget of Hereford and Worcester County Council. The heating system, consisting of boiler house, fuel store, heating mains and pumps, cost € 261 200 in 1997. European Regional Funding, administered by the Ministry of Agriculture, Fisheries & Food, provided € 125 400. Matching funding was contributed by the Department of Trade and Industry through the Energy Technology Support Unit and from Hereford and Worcester County Council.

Resume

Energie-Cités is an association of municipalities whose first priority is to promote sustainable and integrated local energy policies. The association has involved about 150 municipalities in its projects and has more than 90 members from all countries of the European Union.

Energie-Cités objectives include :

- the strengthening of the role of municipalities in energy efficiency, the promotion of renewable energy and the protection of the environment
- to promote debate on the policies and initiatives of the European Union in these fields and publish opinions
- develop municipal initiatives by exchange of experience, transfer of know how and setting up joint projects.

Energie-Cités activities are :

- the dissemination of information on community policies and decisions, municipal best practice and transfer of know how
- monitoring innovative municipal practice and in particular gathering information on best practice, preparation of joint analyses and opinions,
- organisation of events and in particular an annual European seminar.

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The Resources Research Unit in the School of Environment and Development at Sheffield Hallam University specialises in evaluating energy use in buildings, assessing energy efficiency improvements and investigating renewable energy potential as practical means of achieving sustainable development. The Unit has undertaken over 800 energy surveys in non-domestic buildings, including 45 schools, for the Department of the Environment, Transport and the Regions and the Building Research Establishment Ltd., in the United Kingdom. This work contributes to the development of a national database of energy use and carbon dioxide emissions which assist policy formulation in connection with government commitments to the Climate Change Convention. Additionally, the Unit has prepared energy plans for reducing energy consumption and increasing renewable energy use in small and large communities with funding from the Energy Technology Support Unit, in the United Kingdom, and the European Commission. This has involved collaboration with local authorities, including Newark and Sherwood District Council, Sheffield City Council and the Local Authorities' Energy Partnership.

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Associação Nacional de Municípios Portugueses (ANMP)

The National Association of the Portuguese Municipalities (ANMP) is the representative structure of the Portuguese municipalities (municípios) and sections of municipalities (freguesias). It was set up on the 20 May 1984 during its first congress at Figueira da Foz. It has the legal status of a 'collective body of private law', by the strict wish of its respective delegates. All the political parties and all the Regions of Portugal (305 municipalities and 4,241 sections of municipalities of Continental Portugal and the autonomous regions of the Açores and Madeira) are represented in a spirit of brotherhood that expresses the political maturity of its representatives. It is based on dialogue and search for a consensus essential to obtaining the best solutions for the problems of the local population. The main objectives of the association are:

- representing and defending the municipalities and sections of municipalities before the government
- carrying out studies and projects on questions that are within the competence of local authorities
- creating and organising consultative services and technical legal assistance for its members
- developing informative action for local councillors and training of the local administrative personnel
- exchanging experiences and information of a technical administrative nature between its members
- representing its members in national and international organisations.

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OPET NETWORK:
ORGANISATIONS FOR THE PROMOTION OF ENERGY TECHNOLOGIES

The network of Organisations for the Promotion of Energy Technologies (OPET), supported by the European Commission, helps to disseminate new, clean and efficient energy technology solutions emerging from the research, development and demonstration activities of ENERGIE and its predecessor programmes. The activities of OPET Members across all member states, and of OPET Associates covering key world regions, include conferences, seminars, workshops, exhibitions, publications and other information and promotional actions aimed at stimulating the transfer and exploitation of improved energy technologies.

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NOTICE TO THE READER

Extensive information on the European Union is available through the EUROPA service at internet website address http://europa.eu.int

The overall objective of the European Union's energy policy is to help ensure a sustainable energy system for Europe's citizens and businesses, by supporting and promoting secure energy supplies of high service quality at competitive prices and in an environmentally compatible way. European Commission DG for Energy and Transport initiates, coordinates and manages energy policy actions at, transnational level in the fields of solid fuels, oil & gas, electricity, nuclear energy, renewable energy sources and the efficient use of energy. The most important actions concern maintaining and enhancing security of energy supply and international cooperation, strengthening the integrity of energy markets and promoting sustainable development in the energy field.

A central policy instrument is its support and promotion of energy research, technological development and demonstration (RTD), principally through the ENERGIE sub-programme (jointly managed with DG Research) within the theme "Energy, Environment & Sustainable Development" under the European Union's Fifth Framework Programme for RTD. This contributes to sustainable development by focusing on key activities crucial for social well-being and economic competitiveness in Europe.

Other DG for Energy and Transport managed programmes such as SAVE, ALTENER and SYNERGY focus on accelerating the market uptake of cleaner and more efficient energy systems through legal, administrative, promotional and structural change measures on a trans-regional basis. As part of the wider Energy Framework Programme, they logically complement and reinforce the impacts of ENERGIE.

The internet website address for the Fifth Framework Programme is
http://www.cordis.lu/fp5/home.html

Further information on DG for Energy and Transport activities is available at the internet website address
http://europa.eu.int/comm/commissioners/palacio/index_en.htm

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