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The implementation of sustainable energy systems is an objective of the European Union's energy policy. This policy aims to support and promote secure energy supplies with a high quality of service at competitive prices and in an environmentally compatible manner.

The European Commission DG for Energy and Transport initiates, coordinates and manages energy saving policy actions focusing on energy efficiency, maintaining and enhancing security of energy supply and international co-operation. A central policy instrument is the support and promotion of energy Research, Technological Development and Demonstration (RTD), principally through the ENERGIE sub-programme under the European Union's Fifth Framework Programme for RTD. This includes the HOSPITALS project (EU Contract NO: NNE5-2001-00295).

The HOSPITALS project aims to demonstrate the significant reductions that can be achieved in the total energy demand of the European health care building sector. These energy demand reductions will contribute to significant reductions in CO₂ emissions.

BIOCLIMATIC DESIGN CONCEPTS

The hospitals project covers a range of strategies to save energy in buildings, with a focus on hospital buildings. This brochure contains general information, guidelines and strategies for Bioclimatic Design of HOSPITALS.

The brochure aims to illustrate methods of obtaining large energy savings using bioclimatic design strategies from the first stage of building design.

The amount of energy saved and the resulting reduction in CO₂ emissions are quantified. The brochure can be used by all those involved in the process of procuring and designing a health care building.

The primary target groups of the HOSPITALS project are administrators, facilities managers, designers and contractors of health care buildings.

The HOSPITALS initiative aims to demonstrate that renewable energy technologies may be used with very positive results within the European health care building sector and in this way encourage the exploitation of renewable energy.

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Building orientation and form

Objectives:

- the reduction and control of solar radiation;
- the provision of natural ventilation and natural cooling of the external building surfaces by evaporative cooling.

Actions:

- minimize the surface area of the south facing facade;
- at the same time provide for natural lighting and shading;
- avoid excessive solar gain during the cooling season;
- use the roof as an active skin.



View of Deventer Hospital

It is important to consider the local climate during the first stage of building design.

An energy conscious design which results in an energy efficient building has to be based on the local climate.

In a new hospital, the shape and the orientation of the building should be first defined considering the climate of the area, the wind, the temperature and the solar radiation.

It should be decided which areas of the hospital need more solar

exposure and which hospital areas have a high internal heat load and need less solar exposure. The aim is the reduction of the annual energy demand.

It is important to balance the various requirements. Patient comfort is clearly of paramount importance. Environmental impacts, energy consumption and aesthetics are also important but the primary aim when designing a new hospital should not be reducing the energy demand to zero. Nor should the form of the building be considered only in terms of the aesthetic result.



Section view of Meyer Hospital

The section view of the Meyer Hospital shows that it has been designed partly sunk into the hill. This diminishes the impact of the building on the site and contributes to energy conservation by providing shelter so that the hospital is shielded from the prevailing winds by the hill and the trees.

During the design of the building effort was focused on detailed planning and the design of the health care environment. The psychological effects of the environment were taken into careful account. This approach was considered essential for the neonatal intensive care environment and its effect on babies, their families and carers.

Building envelope and materials

Glazing and Double Skin Facade

A building has to guarantee a thermally comfortable indoor environment for the activities that are conducted inside. To optimise thermal comfort it is necessary to reduce the loss of thermal energy through the building envelope.

A Double Skin Facade is an additional external skin for a building that can optimize the indoor climate and reduce the energy demand of the building. The brochure *Double Skin Facade Design* is available for details.

The building envelope of the new hospital building at Fachkrankenhaus Nordfriesland has been designed with high insulation levels and with special attention paid to the windows.

There is a double skin facade with windows which can be opened in the inner skin, parts of the outer skin or both. The windows are designed as sources for supplementary venting and daylighting as well as visual comfort.

Building materials have been very carefully selected, particularly the materials exposed inside the building as these will affect the indoor air quality.

The selection of building materials was based on criteria for: emissions, adsorption, surface roughness and cleaning.

There will not be any PVC materials used within the building and the use of metals is kept to a minimum.

The innovative elements of the building envelope and materials are summarised below:

- Transparent insulation
- Glazing with reduced U-values
- Double skin facades
- Selection of low-emission and low adsorption materials



Internal view of Fachkrankenhaus Nordfriesland

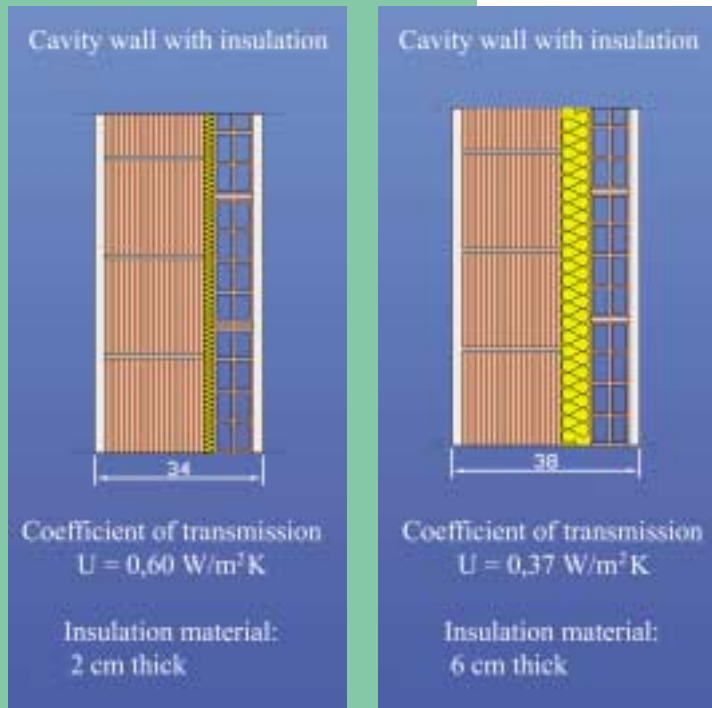


External view of Fachkrankenhaus Nordfriesland

Building envelope and materials

Wall insulation

Energy losses are normally stated in terms of heat flow through a square meter of wall per unit of time. The losses depend mainly on the temperature difference between the inside and outside face of the wall and the thermal resistance of the material, or combination of materials, from which the wall is made.



Energy losses take place through conduction, convection and radiation. The main way of reducing losses is to prevent heat conduction by adding thermal insulation to the envelope.

Cavity insulation: This is an inexpensive way of insulating a wall but it can only be used when a cavity wall is present. Retrospective insulation of the cavity can occasionally create problems. Inspection of the walls is recommended before a decision is made to insulate a cavity. Retrospective insulation of a cavity wall can be done by injecting expanded clay granules, mineral wool flakes or polystyrene beads through a hole into the cavity.

External insulation: This changes the appearance of the exterior considerably. A single, thick insulation layer can be applied, which makes it possible to achieve any desired insulation value. The main advantage is that cold bridges can be easily removed and prevented.

Internal insulation: This is fitted on the inside of the walls of a building. The size of the rooms is, of course, reduced by internal insulation. Inside insulation can give good results when it is carefully executed in order to prevent condensation caused by cold bridges.

Two options for insulating the walls of wards at the Meyer Hospital have been studied. The two drawings above show the options with different thicknesses of cavity wall insulation.

The thicker insulation reduces the energy required for heating resulting in an annual energy saving of about 12%.



100 mm exterior insulation used for Torun Hospital.

Environmentally friendly insulation materials

Conventional insulation materials provide good levels of insulation but may create environmental problems including:

- consumption of limited natural resources e.g. petrochemical based materials
- high embodied energy, particularly during their manufacture
- health problems during installation, e.g. irritating fibres
- health problems once the insulation has been completed, e.g. fibre migration, off-gassing, microbial contamination and degradation
- disposal problems due to synthetic and toxic ingredients

Environmentally friendly materials usually have fewer negative impacts on the environment.

- natural insulation materials are made from renewable plant or animal sources, minimizing the impact on the environment due to consumption of raw materials
- low embodied energy - manufacturing processes are simple using little energy
- there are no health problems during installation
- natural insulation materials are fully biodegradable
- microbial contamination and / or degradation may lead to health problems

NOTE: Health risks may exist with both conventional and environmentally friendly materials when they are not installed and used properly.



Cellulose Fibres



Rock Wool



Installation of wall insulation

Material	Thermal conductivity $\Delta(W/m K)$	Production			Use	
		Toxins	Acid rain	Energy use	Recycleability	Health Risks
Rock Wool	0.03-0.04	3	2	2	2	2
Glass Wool	0.032-0.04	3	2	2	2	2
Polystyrene Foam	0.033-0.035	4	3	4		1
Phenolic Foam	0.036	4	3	4		3
Wool	0.037	0	0	1		
Cellulose Fibres	0.037	0	0	1		
Urea-formaldehyde Foam	0.038	4	3	4		4
Corkboard	0.040	0	0	1	1	
Vermiculite (expanded)	0.047-0.058	0	0	2		
Foamed Glass	0.050-0.052	2	2	3		
Softboard	0.055	0	0	1	1	
Wood-wool Slabs	0.093	1	1	4	1	
Compressed Straw Slabs	0.101	0	0	1	1	

Table: comparing different materials for thermal conductivity. The table also indicates whether there are emissions of toxins or acid rain during manufacture of the insulation and the quantity of energy required for manufacture.

Legend: 1 = low; 2 = medium; 3 = high; 4 = very high.

Key Points

- For a new hospital design: simulate the thermal behaviour of the building to define the optimum insulation thickness and type. The best position for the insulation material is in a cavity wall.
- In a refurbishment, insulate internal surfaces (the depth of the room is reduced); External insulation will change the appearance of the building considerably.
- Insulation material placed on the external surfaces of the walls should be well protected from rainwater.
- It should be remembered that thermal bridges can significantly reduce the efficiency of the insulation used.

Integration of Renewable Energies



Examples of PV systems used as a shading device for an office building (above) integrated into a vertical surface at Fraunhofer ISE Freiburg (below) and installed into an atrium, at the University of Florence, Italy (bottom)



Buildings consume over half the energy used globally and produce over half of all greenhouse and ozone depleting gasses. Today, there is a widespread understanding that we are over-using the earth's limited resources and producing unacceptable levels of CO₂ in order to provide energy.

Use of Renewable Energies is an expensive alternative at the moment but the number of examples of "low energy" buildings is growing in Europe also thanks to the financial support of EU Commission programs.

Photovoltaic (PV) cells

PV-cells convert sunlight directly into electricity. The cells are made of semiconductor materials such as crystalline silicon. Photovoltaics can provide tiny amounts of power for e.g. watches or large amounts for the electric grid, as well as any required power level in between.

PV systems integrated into building facades allow energy production to be combined with other functions of the building envelope, such as shading, weather shielding or heat production. Substantial cost savings can be made through combining these functions, e.g. in expensive facade systems where the cladding costs may equal the costs of the PV modules. Additionally no high-value land is required and no separate support structure is necessary. Electricity is generated at the point of use. This avoids transmission and distribution losses and reduces the utility company's capital and maintenance costs.

Building integration does not just mean mounting PV modules on a building.

Real integration can involve much more; it includes all the steps in the process of new construction or retrofitting a building, starting from planning the production of the construction materials through to operation and recycling.

„Multiple integration“ is perhaps the most appropriate expression.



Above: Meyer Hospital. The surface of the sunspace will incorporate a semitransparent PV system with a rated capacity of 31 kWp of renewable energy.

The Meyer's sunspace is orientated to the south with unobstructed solar access to the main glazing in order to maximize the collection of winter sunshine.

The design objectives consider not only the energy and environmental aspects but also the social impacts: the primary objective is to create a pleasant "socializing" space which can be used for semi-outdoor activities through much of the year without requiring any extra energy. This social space is well integrated with the adjacent green park. The PV installation was financed by the Ministry of Environment after a public and national (Italian) competition called "PV in the Roof: High Architectural Integration"



Left: Fachkrankenhaus Nordfriesland

The large ceiling surface has a shallow north facing slope; here a white curtain is used to reduce solar radiation. On the south facing steeply sloping roof section, polycrystalline PV modules are integrated into the glazing to act as solar shading while generating electricity.

Solar water-heating systems

Solar water-heating systems use solar collectors, generally mounted on a south-facing roof, to heat either water or non-toxic antifreeze that is circulated from the collector to water storage tanks. The water storage tanks are similar to those used in a conventional gas or electric water heating system.

At Aabenraa hospital three solar collector systems were implemented, one for each of the ward sections, B and C and one for the surgical section K. All the systems were roof mounted. For architectural reasons and in order to avoid glare the solar collectors were mounted so that they were not visible from outside the building. Two different system types were considered: a drain back system and a standard system with anti-freeze liquid. Both systems have advantages and disadvantages, which were evaluated in order to identify the most attractive system. The standard system with anti-freeze liquid was chosen, because this allowed the existing hot water tanks to be used rather than replaced as would have been required for a drain back system.

Special attention was given to the risk of legionella bacteria. Risks were minimised by using an electrical backup system to ensure that the high water temperatures required for avoiding legionella growth were always achieved.

Each system includes approximately 50 m² solar collectors, which provides an annual energy yield of about 27 MWh per system. This provides about 60% of the annual energy requirement for water heating.



Solar Collectors at Aabenraa Hospital

Building integration of solar energy technologies

The design of high-performance buildings involves combining good design with energy efficiency and solar technologies to reduce energy consumption.

Solar technologies tap directly into the infinite power of the sun and use that energy to heat, light, and power buildings. Solar technology combines building design and energy efficient technologies with solar thermal panels for heating water or solar electric panels (photovoltaics) for powering electrical items such as appliances, lights and computers.

Green Roofs

To reduce heat losses it is necessary to insulate all opaque elements in a building, including the roof.

A greenroof can insulate a roof and at the same time help to protect the environment by diminishing the environmental impact of the building. Green roofs can provide a fresh architectural approach with visually appealing organic architecture.

It is assumed that a good environment has a positive influence on the recovery of patients. Hospital buildings should therefore be considered as a part of the treatment of patients.

Selecting building materials with low levels of emissions such as green roofs can lead to an improved indoor climate, which will benefit the patients.



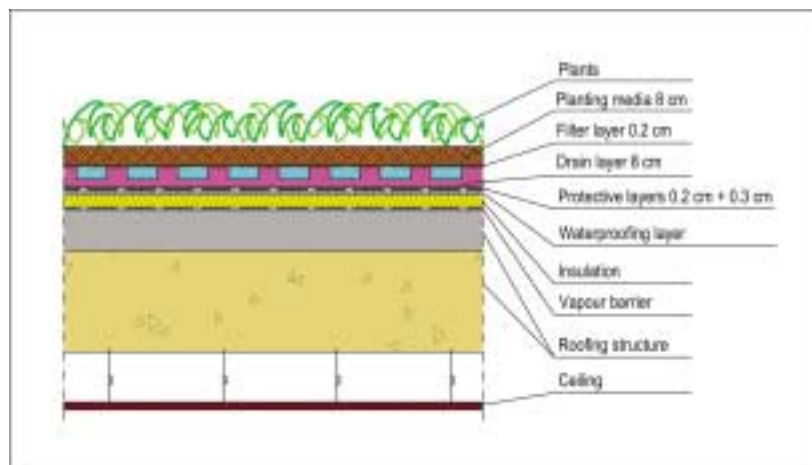
A green terrace solution is planned for the Meyer Hospital. The final design, with increased amounts of insulation material in the cavity walls and a green roof - reduces the annual energy demand for heating by 36% per patient room.

Notes

- When refurbishing a flat roof which is suffering from water infiltration, care should be taken to ensure that the insulation material is replaced with a sufficient gradient.
- It should be remembered that the advantage of pitched roofs is that rainwater flows off easily; they therefore require less waterproofing than flat roofs.
- A flat green-roof may be used as a garden by patients, and is recommended as an environmental benefit.
- Avoiding the use of traditional roof construction materials reduces the materials that have to be transported:

transport of materials accounts for a high proportion of carbon dioxide emissions;

- the choice of an environmentally friendly material as an insulation material usually has an extra-cost. It is important to evaluate the extra cost and the pay-back period and relate this to reductions in carbon dioxide emissions.



Section of the greenroof used at Meyer Hospital

Water

The rational use of water is an important issue for saving water resources. It has to be taken into account from the first stage of the design.

Collected rain water can contribute to maximizing the thermal comfort during the summer season when used in external spaces or atria to provide water to fountains, ponds and pools. These architectural elements are able to mitigate and influence microclimate and provide patients with a relaxing area and view.

How does water influence the microclimate?

Evaporation occurs whenever the vapour pressure of water is higher than the partial pressure of the water vapour in the adjacent atmosphere.

The evaporation of water from liquid to vapour is accompanied by the absorption of a large quantity of sensible heat from the air that lowers the dry bulb temperature of the air while the moisture content of the air is increased.

The efficiency of the evaporation process depends on the temperatures of the air and water, the vapour content of the air and the rate of airflow past the water surface.

The main disadvantage of a pond or a fountain is the increased moisture content in the ventilation air supplied to the indoor spaces.



Psychological aspects are very important for hospital patients. Patients need a friendly place to recover from sickness.

On this page:
Lake and pond in Fachkrankenhaus
Nordfriesland



The building, plus the specialized medical team and the environment, is an important part of that place. Plants and water in the buildings and external areas give patients contact with nature, providing a relaxing hospital environment in which to recover.

Daylight Strategies

An energy conscious building aims to optimise the use of passive solar energy, natural ventilation and natural light to create a comfortable and energy efficient working environment.

The use of daylight for interior illumination can reduce energy use within buildings and has a positive effect on visual comfort.

If considered at the design stage, the use of daylight allows for a significant reduction in electricity used for lighting and can reduce the overall energy consumption. Daylighting depends on the availability of daylight, location, size and orientation of windows.

Several strategies can be used to achieve visual comfort when using daylight including: Rooflights, Atria, Glazing, Transparent Insulation, Lightpipes and Lightducts, Shading.

Integration of rooflights

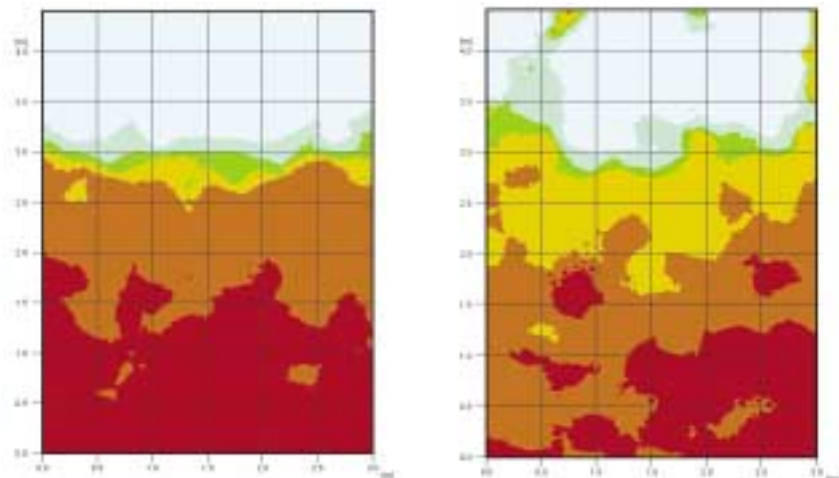
Integration of rooflights is an effective daylighting strategy. The sky is generally brighter at its zenith than near the horizon: this is the reason why horizontal rooflights admit more daylight per square metre of glazed area than vertical windows (three times more than a vertical window).



Shading devices at Aabenraa Hospital.



Daylight strategies (roof windows) used in the atria at Aabenraa Hospital.



Illustrations showing the daylight distribution in two rooms facing the glazed courtyard at Aabenraa Hospital: The daylight levels were not reduced by the glazing of the courtyard; on the contrary the daylight levels and distribution were improved after glazing the courtyard. The use of energy for lighting during daytime is expected to be reduced by approximately 50% compared to a conventional design.

Sunpipes

Sunpipes are among the more mechanically complex daylighting devices.

Sunlight is collected by heliostats (mirrors controlled by a tracking device), concentrated by mirrors or lenses, then directed inside the building through shafts or fibre optic cables.

Sunpipes depend on direct sunlight and are relatively expensive to install: for these reasons they will be cost-effective only in regions where blue skies and clean air can be guaranteed for most of the year.



Left and above: pictures of the sun pipes used at Meyer Hospital for daylighting. Sun pipes were installed to give good luminance levels in each patient's room. Each room accommodates two patients and has two windows, one looks outside and is day lit, the other is illuminated by sun pipes. At first sight the sun pipe installation gives the impression of being lamp lit.

Shading

The type, size and positioning of any shading device will depend on climate, building use, and the source of the light to be excluded (direct sunlight, diffuse sky light, or perhaps reflected light from outside).



Shading system at Fachkrankenhaus Nordfriesland Hospital

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Information about The Fifth Framework Programme is available at the following website:
<http://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/energy/res/index_en.htm

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