An overall objective of the European Union's energy policy is to help to ensure implementation of sustainable energy systems by supporting and promoting secure energy supplies with high service quality at competitive prices and in an environmentally compatible manner.

The European Commission Directorate Generale for Energy and Transport initiates, coordinates and manages energy saving policy actions focusing on energy efficient use, maintaining and enhancing security of energy supply and international cooperation.
A central policy instrument is its 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.

HOSPITALS aims at demonstrating the significant potential for reducing energy demands within the European health care building sector. Reducing energy demands within the sector will contribute to significant reductions in CO_2 emissions.

DESIGN HANDBOOK ON ENERGY CONSCIOUS HOSPITAL AND HEALTH CARE BUILDING DESIGNS

This handbook gives an introduction to strategies for saving energy in buildings with focus on hospitals and health care buildings. It has been developed for the HOSPITALS project (Project No. NNE5-2001-00295) supported by the European Commission.

The handbook is aimed at all parties involved in a health care building project, and it underlines the possibilities of obtaining large energy savings by using an Integrated Energy Design Process.

The primary target groups of the HOSPITALS project are administrators, facility managers, designers and contractors of health care buildings. The HOSPITALS initiative will also demonstrate that renewable energy technologies may be used with very positive results within the European health care building sector and by this encouraging the use af renewable energy.

List of Contents:

HOSPITALS

Aabenraa Sygehus, Denmark

Fachkrankenhaus Nordfriesland, Germany

Meyer Children's Hospital, Italy

Torun City Hospital, Poland

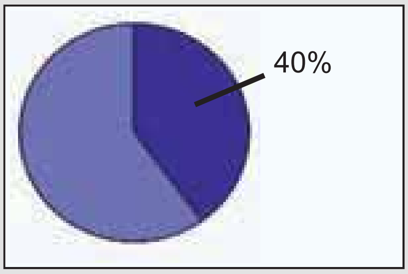
Deventer Hospital, Netherlands

EU Proj. No:
NNE5-2001-00295

Supporting Organization
European Commission

Introduction

Why energy conscious designs?



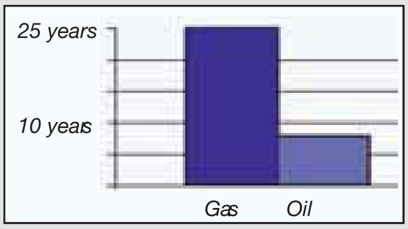
40% of the energy demand in the EU is consumed by the building Sector.

The present energy demand situation in the European Union is critical with approximately 50% of the total energy demand having to be imported. More than 40% of the total energy demand is due to building sector requirements for electricity and heating. The decreasing fossil fuel reserves and the increasing tendency to import energy require immediate action to cut down energy demands in the building sector.

Table 1 shows the average energy demand for different types of buildings (offices, schools, private residences and hospitals) in three different European countries.

Building type	Denmark	Germany	The Netherlands
	kWh/m² per year	*kWh/m² per year*	*kWh/m² per year*
Offices	146	127	57
Schools	147	99-149	110
Private residences (1 family)	169	222	193
Hospitals	249	*Not available*	353

Table 1. Average annual energy demand for different building types in three countries.



Gas and oil reserves in the EU member strates if consumption continues at the current level.

In Denmark, Germany and the Netherlands the energy demand for the different building types varies, however it is clear that hospital buildings are one of the most intensive energy consumers in the building sector.

Implementation of energy conscious designs would contribute significantly to the reduction of overall energy demand in European buildings. As high energy consumers, hospital buildings could play a very important role. Buildings in the health care sector are often very complex and new building services and designs are developed to meet their requirements. Solutions for this sector are often then transferred to other types of commercial buildings, which means that an energy conscious approach for the health care sector would contribute to improved designs in other sectors as well.

Health care sector

HEALTHY HOSPITAL BUILDINGS CAN INCREASE THE SPEED OF RECOVERY

There are several type of Hospital buildings in Europe. In some countries, the health care sector is largely centralized and therefore the majority of the hospital buildings are large hospitals. Other countries have a decentralized health care structure with many small hospital buildings.

Building development within the health care sector is becoming more and more complex as health care requirements get more complex. Many hospitals have specific needs, which require specific mechanical and electrical (m&e) installations. At the same time, the hospitals also desire a high level of flexibility. It may not be possible to meet these conflicting demands simultaneously. For example, the acoustics in a health care centre need to be kept low, so certain types of materials are required for surface finishes. However, these types of materials may not have easily maintainable surfaces.

Traditional building practice focuses on the investment costs rather than the long term running costs of a building. This can be a barrier for the implementation of energy conscious designs, as the initial investment costs may be slightly higher, although future running costs would be significantly reduced.

Glazed buffer space at Meyer Children's Hospital (Italy)

Within the health care sector, the building owner and the building user are normally part of the same organisation. This sector therefore provides good opportunities to invest in long-term building performance with the focus on running costs, including energy demand.

In new hospital buildings a considerable proportion of the investment often goes towards medical equipment and technical installations for medical purposes. On a political level, it is often easier to advocate investments for medical purposes than for improvements in building quality. The energy efficiencies of the medical equipment should therefore be considered as well as the normal building energy efficiency.

In many countries, the administrative and financial arrangements for a hospital do not encourage investment in energy efficiency. Often, if financial savings are made through energy efficiency, these would automatically be withdrawn from the next year's budget. It is necessary to change this mechanism if European hospitals are to be motivated to invest in energy conscious designs.

Glazed buffer space at Meyer Children's Hospital (Italy)

In the Netherlands, hospitals receive a fixed annual budget for energy costs, thus financial savings from improvements in energy efficiency are beneficial to the hospital. If the health care sectors in EU member states were motivated to implement energy conscious designs, they would be able to provide patients with healthy and energy efficient hospitals.

Energy conscious designs

What characterises energy conscious designs?

When designing buildings with the purpose to reduce the overall energy consumption and improving the indoor climate, a large number of issues have to be taken into account. These issues concern the building itself, the future use of the building, the building services and energy infrastructure, and the economic conditions for investment, running and maintenance costs.

Exterior view of Meyer Children's Hospital (Italy)

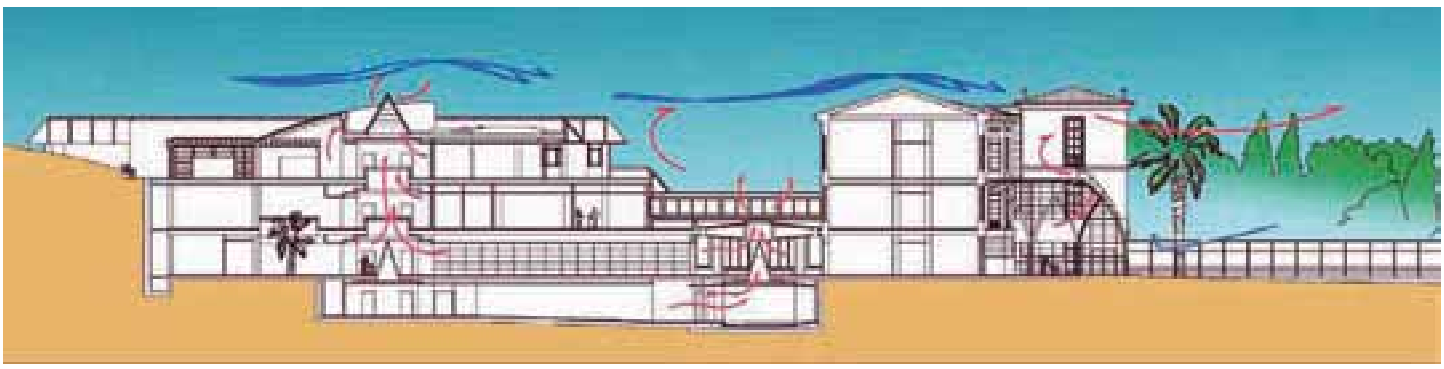
Guidelines on these issues will be given later in this handbook. Before dealing with these details, a number of initial questions need to be asked to the decision makers, the design team and the users of the building:

- The decision making path?
- The indoor climate required?
- The level of flexibility required?
- Economic assessment method, i.e. how to compare investment costs and running costs?

- make the building and its services work together with natural forces and not against them

Most buildings are not designed using an energy conscious design strategy. Instead, the design process focuses on dimensioning the different parts of the building to manage extreme situations, which might only occur a few days of the year. The rest of the time these buildings are running in a relatively inefficient way and the annual running costs are far higher than they ought to be.

Energy conscious designs focus on achieving comfort for the users through a methodology where the forces of nature (solar radiation, wind, evaporation, shadows etc.) are considered in the design of the building shell, in the use of materials and in defining the strategies for operation. This leads to buildings where the mechanical and electrical (m&e) installations and services work together with natural forces and with the building itself to create comfort with a minimum of energy use.



Visualisation of wind driven and themal buoyancy effects at Meyer Children's Hospital (Italy)

Stakeholders and interests in the design process

Implementation of energy conscious designs involves several different stakeholders who must be involved at an early stage of the process if the overall goal of a good indoor climate and low energy costs is to be fulfilled. Examples of stakeholders include:

- **Politicians**, who decide the overall infrastructure of the hospitals sector, economic framework, fiscal years and often also set the priorities for the function, capacity and possible expertise of the hospital.
- **Investors**, who nowadays are often partners in the process through PPP (Public Private Partnerships), where private investors finance the design, construction and operation of public building projects.
- **Client / Building owner**, who has the overall responsibility for the building, its operation and the costs linked to it. Can be public, private or a combination in the case of shared ownership.
- **Users**, covering a large and varied selection of specialised groups of employees and various types of patients and their relatives.
- **Architect**, typically with responsibility for the overall aesthetic, all floor plan lay-outs and interior design.
- **Consultants**, typically with an engineering background, have responsibility for the structure, m&e installations and services and the interface between medical equipment and the building.

The building shall be robust and adapt to the users - not the opposite!

A *motivator* will often play a key role in the process of achieving an energy conscious design

Experiences from hospital building projects show that a **motivator** is an important participant. The role of the motivator is to catalyse the process and help the design team meet the targets regarding energy use and indoor climate.

The motivator can be an external party, a politician, local authority or one of the participants in the design team, as long as the role of the motivator is accepted and respected by the whole team.

The building process at Meyer Children's Hospital

A key criteria for successful collaboration within the design team is awareness of the different needs, requirements and goals of the different stakeholders. A few general examples are given below:

The building owner also often represents the investor and his various expectations. Key concerns of the client are usually function and costs (investment, and running costs). Due to financial constraints and a restrained time schedule, it is important that the building owners specify their requirements for the building and how investment costs and running costs should be compared early in the project.

The users of the hospitals are often the most difficult to represent in the design team in an efficient way. The various users have very different requirements, from the specialised requirements of the intensive care unit to providing good and relaxing facilities for relatives of patients.

Implementation of energy conscious design requires team work (GTA)

The client needs to specify at an early stage how the design team should compare investment costs and running costs (Peter Weber/Tony Stone images)

*Visualisation of bed-ward at **Deventer Hospital** (the Netherlands)*

In the design process it is necessary to obtain input from the users through professional organisations, key-persons and through the various interest organisations for different groups of patients.

Implementation of energy conscious design requires involvement and participation, from the beginning, of all the relevant actors. If good communication between the different parts of the design team does not occur from the start, there is a tendency for the collaboration to develop into a rather hostile negotiation where none of the actors wants to take responsibility.

To achieve good communication and consensus about the prioritisation of the various issues, planning at the early phase is essential. An important aspect of this planning is the sequence of decisions and a common understanding that the design process of buildings, especially seen from the architects point of view, is an iterative process where the design is progressed through refinement of earlier designs based on new information and details gained during the process.

It is especially important for the *motivator* to recognise this iterative process and he shall stimulate the process by constantly reminding the design team of the overall goals and stimulate the design efforts to focus on the critical points which are likely to have a large influence on the comfort and energy performance of the building.

An important aspect of the design process is the structure of payment for the different actors, especially the architect and the consultants. Traditionally design fees are calculated based on a percentage of the total building costs, so the more HVAC components the consultant can convince the client are necessary to run the building, the larger his fee for the consultancy. An improvement in performance e.g. a reduction in energy demand through better planning, use of natural ventilation, thermal mass and saving some m&e services will have a neutral or negative effect on the fees. In other words, with the traditional structure of payment there is no incentive for the architects and consultants to identify or develop savings to the client. This leads to an unbalanced situation, where the client and design team have different targets and motivations.

To overcome this, the contract can be based on a standard fee based on a typical building with typical operation costs, with an incentive structure so that reductions in investment costs or savings in the running costs increase the fee of the consultants and vice versa.

Hospitals - complex buildings with general requirements

Hospitals are complex buildings with several different departments:

- Bed-wards
- Treatment departments
- Out-patient's clinic/Poly-clinic
- Service department
- Administration and Technical department
- Special functions
- Kitchens
- Sanitary facilities, Laundry etc.
- Halls, distribution tunnels and basements
- Dwellings for students, teachers, doctors, nurses etc.

Each department has its specific needs and requirements from the building. Even though most hospital building projects are unique projects with specific requirements, the majority of such projects end up with the same general issues and questions regarding indoor climate conditions:

- What are the requirements in the design brief?
- What is the size of the glazed area and the light transmission through the glazing?
- What are the requirements for solar shading and glare control?
- What are the internal loads?
- Which ventilation levels are required?
- What is the potential for using renewable energy resources?

Often the requirements are specified at very different levels. Some functions have very specific air exchange rates, maximum temperatures, minimum lighting levels etc. which even may be defined in national standards or codes. If these specific requirements are the result of a thorough analysis this is excellent for the design team, however, very often these specifications are not related to real requirements for comfort and function.

To ensure that the real requirements are being met, the design team needs to work very carefully to obtain the real comfort, visual and functional requirements of the various groups, preferably expressed in their own words. These requirements can then be "translated" into the technical requirements to be used in the analysis of various design options.

This process requires a common understanding of what is considered a satisfying indoor climate, which is considered in the following section.

What characterises a satisfying indoor climate?

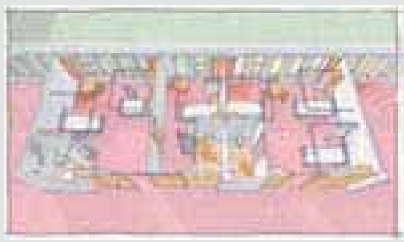
The definition of a satisfying indoor climate is one where the users of the building experience thermal comfort and high indoor air quality. Thermal comfort is often defined as a state of thermal neutrality, i.e. when a person does not wish to be warmer or colder. In literature and HVAC codes, guidelines are provided for the right combination of air temperature, moisture content, radiant temperature from surroundings and air speed for different activities and levels of clothing.

The quality of the indoor air includes all the non-thermal aspects of the indoor climate which influence the comfort and health of the occupants. The most important contaminants of the indoor air are: bio effluents from people, tobacco smoke, organic vapours, radon, humidity, combustion products, fragrances, particles, fibres, bacteria and viruses. The concentrations of these contaminants can be restricted or eliminated by ventilation or filtration.

Common patient recreation area in ***Aabenraa Hospital***

The buildings themselves do not have an energy demand - the users of the building do!

Solar shading of glazed court-yard at ***Aabenraa Hospital***



Bed-wards at ***Deventer Hospital*** *(the Netherlands)*

Air photo of Meyer Children's Hospital (Italy)

Model view of Deventer Hospital (the Netherlands)

A satisfying indoor climate provides better working conditions for the working staff, fewer working days lost through sickness and higher productivity. In hospitals, a comfortable indoor climate will also provide patients with a better environment for rehabilitation and consequently earlier discharges of people would be expected. (This effect has been observed at the hospital in Aabenraa, DK).

A key issue in setting the goals for a satisfying indoor climate is the recognition of the fact that m&e installations and services only provide part of the solution to providing a good indoor climate and low energy consumption. The energy and indoor climate performance of the building itself, often referred to as the passive performance of the building, is even more crucial and will be further described in the following section.

Passive performance of a building

The passive performance of a building is determined by its physical characteristics:

- Orientation of the facades
- Width, height and depth of the different parts of the building
- Glazing to floor ratio
- Type of glazing
- Shading characteristics of the building itself (overhangs etc.)
- Availability of daylight (roof lights and side lights)
- Insulation levels
- Exposed thermal mass e.g. concrete floors, slabs or ceilings
- Possibilities for free air flow through the building interior
- Interior lay-out (concentration of internal heat gains from persons or equipment)

These are the primary elements which influence the indoor climate and the overall energy consumption of the building. Open collaboration between the architect and the consultants is crucial to allow benefits to be obtained from the optimum combination of these elements. A building with optimized physical characteristics is the best starting point for obtaining an optimum indoor climate. The m&e installations and services can then be used when necessary to supplement heating, cooling and ventilation needs with minimized energy consumption.

The passive performance of a building is specific to its location. The same building will perform differently under different conditions of:

- Solar radiation, solar height and duration
- Prevailing wind, wind speeds and gusts
- Precipitation
- Quality of outdoor air (dense urban or rural)
- Traffic noise

In the following chapters an *integrated energy design* methodology will be presented. This has been developed to allow the design team to benefit from the passive performance of the building and combine this with the more traditional HVAC-design issues to achieve an optimum indoor climate and provide a building with a high degree of flexibility and minimum energy demand.

Integrated energy design

The integrated energy design approach

With the criteria for a satisfying indoor climate defined, the next step is to identify the actual processes and methods to achieve the required level of comfort.

The indoor climate of a building is influenced by many parameters including ventilation, operational strategies, daylight properties, draughts, maintenance etc. It is essential to treat the chosen parameters in a well-considered order to achieve effective implementation of energy conscious designs.

The approach to integrated energy design has to be well-considered

The figure below describes the general approach to an integrated design process with architectural integration of bioclimatic strategies. The left column represents winter and summer situations, together with light and ventilation strategies. The top row signifies the evolution of the design from a macroscopic view, starting at the urban level (placement and the surrounding infrastructure for the hospital) to a microscopic very detailed view (construction materials used and building management).

	Urban	District	Building	Element	Material	Manage-ment
Winter (heating)						
Summer (cooling)						
Light (daylight properties)						
Ventilation (natural ventila-tion)						
Building Energy Management System (BEMS)						

Architectural integration of bioclimatic strategies

The general approach towards an integrated design process would be to use this figure to generate a matrix, which would represent the characteristics of the actual building.

In order to ensure that the building itself contributes to a good indoor climate and low energy demand, the various design issues should be treated in a certain order to make maximum use of the passive features of the building before planning the m&e installations. A recommended and prioritized sequence is given below. The prioritized order reflects the level of freedom for decisions and gives priority to the passive performance of the building.

*Skylight forventilation purposes in **Aabenraa Hospital** (Denmark)*

Energy supply: Infrastructure and conditions for current and planned available energy supplies (types of power stations nearby, district heating, wind, biomass etc.).

Structure: Physical boundaries (placement, orientation, building type etc.) and the layout of areas within the hospital; considering movement of people and equipment and grouping together areas with similar requirements, e.g. day time use, ventilation, cooling, access to the x-ray department etc.).

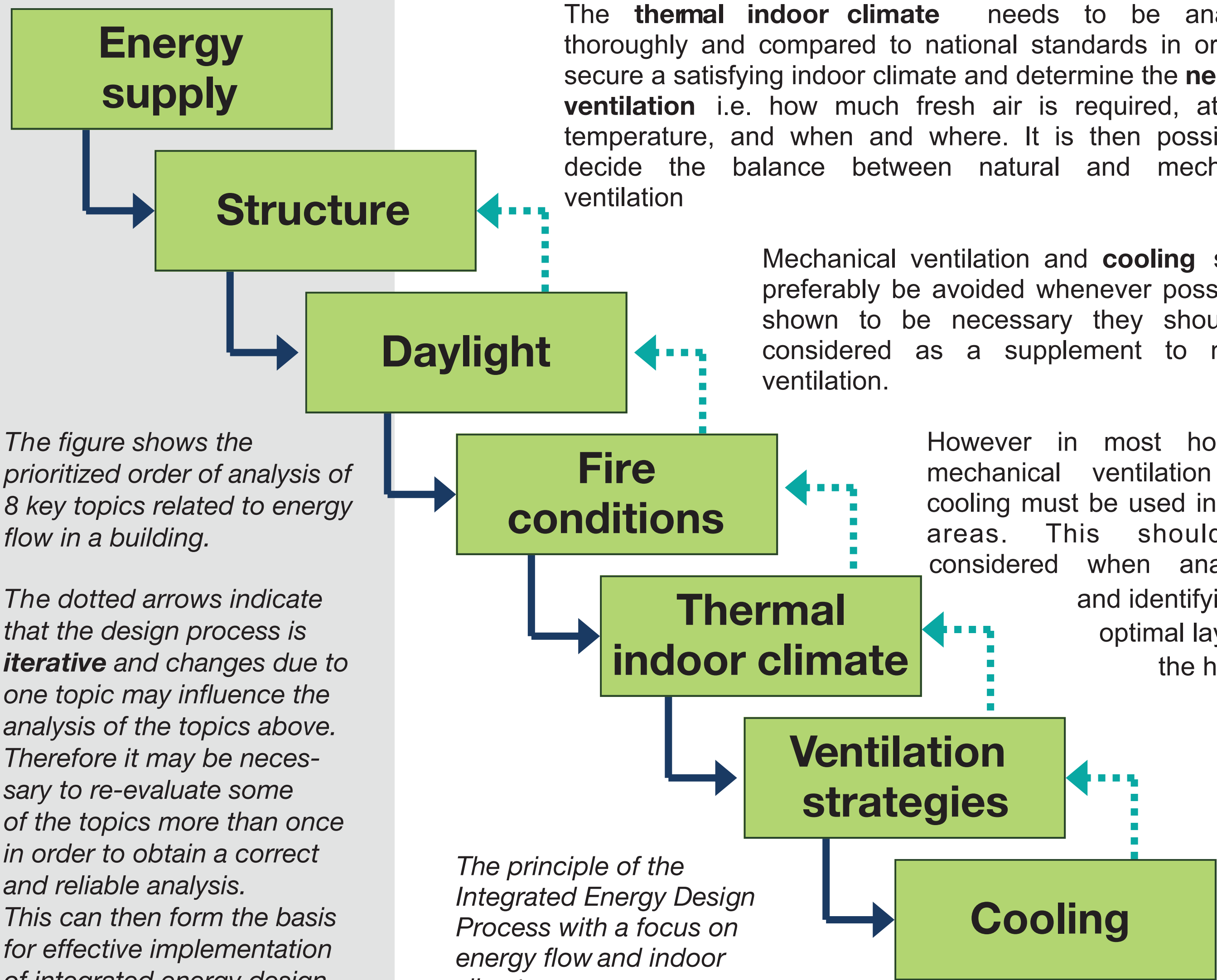
Daylight: Planning daylighting strategies early is crucial in order to obtain maximum energy saving from artificial lighting and good visual conditions.

Fire conditions are closely connected to the choice of **ventilation strategies**, as openings for natural ventilation can be used for smoke ventilation as well, which may lead to avoidance of complicated and expensive sprinkler systems.

The **thermal indoor climate** needs to be analysed thoroughly and compared to national standards in order to secure a satisfying indoor climate and determine the **need for ventilation** i.e. how much fresh air is required, at what temperature, and when and where. It is then possible to decide the balance between natural and mechanical ventilation

Mechanical ventilation and **cooling** should preferably be avoided whenever possible, if shown to be necessary they should be considered as a supplement to natural ventilation.

However in most hospitals mechanical ventilation plus cooling must be used in some areas. This should be considered when analysing and identifying the optimal layout of the hospital.



The principle of the Integrated Energy Design Process with a focus on energy flow and indoor climate

The figure shows the prioritized order of analysis of 8 key topics related to energy flow in a building.

*The dotted arrows indicate that the design process is **iterative** and changes due to one topic may influence the analysis of the topics above. Therefore it may be necessary to re-evaluate some of the topics more than once in order to obtain a correct and reliable analysis.*
This can then form the basis for effective implementation of integrated energy design.

As hospitals are energy intensive buildings containing a lot of energy consuming equipment it is also relevant to consider the **efficiency** of all the equipment within the hospital as improving equipment efficiencies could reduce energy demand significantly. For renovation projects in particular this may be more cost effective than installing new building service systems, (e.g. new heating or ventilation systems), or modifying the building fabric.

By using a deliberate approach to implementation of integrated energy design, the energy demand of the hospital will be reduced to a minimum and the passive performance of the building will be utilised effectively.

In the following each of the eight topics will be presented in detail with an explanation of how to proceed in the analysis and what tools to use.

In existing hospital buildings it is often beneficial to focus on the efficiency of the hospital equipment *before* implementing new building services in order to reduce the energy demand.

Energy Supply

The energy supplies to a hospital building can be divided into three categories:

- Energy supply for electricity purposes
- Energy supply for heating and ventilation purposes
- Energy supply for domestic hot water (DHW)

Before implementing energy conscious designs, it is important to determine the available energy supplies to the hospital and undertake a detailed analysis and optimisation of the different options for energy supply. This also includes an analysis of the control, management and maintenance of the energy supply system.

Equally important is it to co-ordinate with local energy supply plans, which increasingly aim to implement innovative energy technologies. Various issues can arise. For example, if relatively cheap district heating is available from a CHP plant, the availability of cheap heat could be a barrier for the utilisation of renewable energy for heating purposes, unless considered at an early stage of the planning. In other cases, the energy supply system for the hospital could be considered as part of the overall capacity generated for the area.

Deventer Hospital (NL) *The building is organized in defined zones each with specific energy requirements*

Structure

The structure and layout of a hospital building is not randomly chosen, but depends on several parameters which influence placement, physical appearance and the organization of areas within the building. Accessibility is a key word for hospital buildings, as it should be easy to travel to and from the hospital in ambulances, public or private transport. Energy is another key word particularly in terms of building layout and use patterns over a 24 hour period. It is important to understand the needs of the client and identify the purposes for which the building will be used and the space and time requirements.

The organizational structure of the hospital can determine the physical shape of the building, not only its actual size (small/large hospital), but also how the building is organized according to internal activities. Definition of the organizational structure of the hospital ought to take place at the beginning of the design process, as it forms the foundation for implementation of integrated energy design.

*Solar heating system on the roof at **Aabenraa Hospital** (Denmark)*

*Hot water storage for the solar heating system at **Aabenraa Hospital** (Denmark)*

Daylight

Daylight is defined as the diffuse part of sunlight, i.e. the light is dispersed in several different directions. This is the opposite of direct sunlight. Direct sunlight can be re-directed and transferred with a mirror, for example, whereas daylight cannot easily be re-directed. Therefore it is important to take daylight properties into consideration at an early stage in the design process of a building.

It has been proved that most people prefer daylight with its' natural variation in strength, colour and direction, which is very different from artificial light. Used as the primary light source, daylight can provide stimulating effects and is therefore an important parameter in the studies of the indoor climate in a hospital building.

*Top lighting in courtyard at **Aabenraa Hospital***

Daylight is also an energy effective light source relative to the heat contribution, as presented in the table below.

Source of light	Efficacy [lumen/Watt]
Daylight	70-80
Metal halide	65-100
Compact fluorescent tube	35-93
Halogen incandescent lamp	12-27

Efficacy of different lighting sources

*Glazed courtyard in **Aabenraa Hospital***

Optimal utilisation of daylight means less artificial light and therefore reduces the electricity demands for lighting purposes and may also reduce internal heating loads.

In hospital buildings there are departments where it is necessary to use artificial light sources, for example in operating theatres and other special treatment sections, but daylight can profitably be used in bed wards and open rehabilitation areas. In Aabenraa Hospital (Denmark), the renovation plan has involved glazing of existing courtyards in the middle of the building, providing optimal daylight utilisation. Investigations have shown that the possibility of sitting in the day rooms in the courtyard, with their attractive visual and thermal comfort conditions, provides an incentive for patients to get out of bed faster, implying that the patients rehabilitate faster.

Daylight properties are often expressed by the daylight factor (DF). The daylight factor is defined as the ratio between the daylight available on a planar surface in a room in a building (G_{inside}) and the daylight available on the same un-shaded planar surface outside in cloudy weather conditions ($G_{outside}$).

Since more than 75% of the daylight incident on the façade of a building, originates from sky directions between vertical and 45° off vertical, windows in the upper part of the façade of a room, provide the best daylight distribution within the room, while "low windows" provide poor distribution of daylight.

Building codes regarding daylighting requirements vary from country to country. For example, the Danish National Inspection of Workplaces code requires sufficient access to daylight for rooms in a general workplace, and states that this normally occurs when either the window area (in the façade) corresponds to 10% of the floor area, or the top lighting (in the ceiling) corresponds to 7% of the floor area. Alternatively, it would be sufficient to demonstrate by measurement or calculation that the average daylight factor will be 2%.

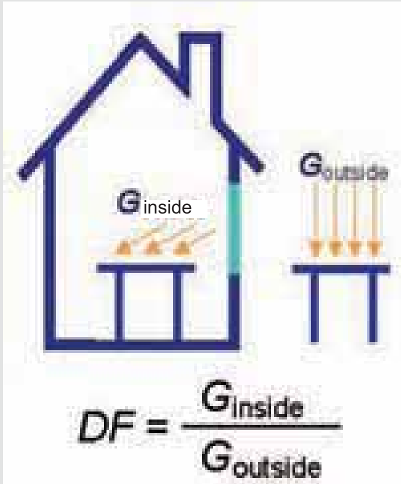
Several tools are available for calculations and simulations of daylight properties. The simpler tools are based on luminance models and give results showing the luminance distribution in a room, including the daylight factor. Advanced tools are based on ray tracing models. These are utilised if the building geometry is very complex and/or the surfaces are dominated by highly reflective surfaces. When analysing daylight properties, it is important to ensure that the orientation of the glazed areas is optimised so that there will be no problems with glare.

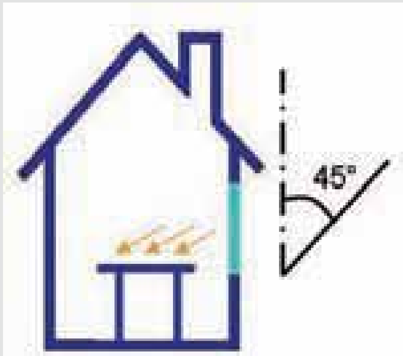
Fire Conditions

Depending on the national standards there are several ways to secure fire safety conditions in a building. If natural ventilation is planned as the ventilation strategy the design can benefit from co-ordination between the openings required for smoke ventilation and the openings required for natural ventilation. Usually, the openings required for smoke ventilation are larger than the openings required for natural ventilation.

In several countries the fire safety strategy can be based on efficient evacuation, smoke detection and ventilation. When combined with requirements for natural ventilation, sprinkling can be omitted in parts of the building.

Most people prefer daylight as the primary light source





More than 75% of daylight originates from directions between vertical and 45°

Examples of simple simulation tools for daylight calculations:
- ***Daylight***
- ***Relux***

Examples of advanced simulation tools for daylight calculations:
- ***Adeline/Radiance***
- ***Argos***

Examples of simulation tools for fire:

- ***CFD (Fire dynamics simulator)***

The tools used for analysing and optimising fire conditions are specific fire simulation programs which determine how a fire would develop under specific conditions and simulate evacuation scenarios. In hospitals it is important to be especially careful with fire and evacuation conditions as many users of the building are bedridden.

For the simulation of smoke distribution in a fire situation computational fluid dynamics (CFD) tools are used, providing a detailed understanding of how smoke is spread in the building. CFD can also be used for the simulation of natural ventilation, as described later in this handbook.

Thermal indoor climate

*Visualisation of day room at **Deventer Hospital** (the Netherlands)*

The thermal indoor climate analysis uses as input the parameters determined in the previous topics and provides information for the next topics in the design process, i.e. the ventilation and cooling requirements.

In order to conduct a high quality analysis of the thermal indoor climate of a hospital building, it is important to include **all parameters** which influence the indoor climate and the perception of the people who use the building on a daily basis (patients, employees, visitors etc.). This means that it is necessary to analyse the effects of the dynamic use of the building as well as the static characteristics of the building. The dynamic characteristics include the heat load from people, computers and technical equipment, daylight and sunlight, whereas the static characteristics are defined by the building envelope and materials.

*Common patient recreation area at **Aabenraa Hospital** (Denmark)*

In many countries the specifications for m&e services are based on "over-dimensioning" the building services to be able to cope with extreme situations without taking into consideration the low probability of all extremes occurring simultaneously and without taking into consideration the dynamic effects, such as thermal storage.

With the improvement of simulation tools and experience from monitoring existing buildings, it is now possible to get a good understanding of the critical parameters influencing the thermal performance of a building and to provide a more flexible and dynamic design approach. The comfort experienced in such buildings is as good or even better than traditionally designed building, but this high level of comfort is provided with much lower energy consumption.

*Visualisation of reception at **Deventer Hospital** (the Netherlands)*

The key tools used for analysis of the thermal indoor climate are dynamic simulation tools, which can provide hourly simulations of a single room or complete building under various climatic conditions. The software, which includes dynamic characteristics, calculates overheating risks and monitors whether obligatory national standards can be fulfilled or not. Many simulation tools involve calculation of heat losses, energy demands and simulation of regulation strategies.

Due to the complexity of the tools, the user needs to have sufficient theoretical and practical understanding of building physics to make the right simplifications and decisions and to properly evaluate the results, especially when judging the quality of the thermal indoor climate.

Each country has different standards for the thermal indoor climate for different types of building. The most important parameters are air velocity, air temperature and contamination within the room. These parameters must be within certain limits in order to achieve a satisfying indoor climate.

According to e.g. Danish standards, less than 10% of the users will be dissatisfied if the operative temperature is:

Normal conditions, general dress : $20°C < T_{operative} < 24°C$
Summer conditions, summer dress : $23°C < T_{operative} < 26°C$

Draught problems can generally be avoided if the air velocity in a room is within certain limits, for example an average air velocity (V_{air}) of 0.15 m/s with an indoor temperature T_i of 22 °C and a turbulence intensity of 40% (Danish standards).

Contamination by CO_2 is often used as an indicator of air quality which can be converted into necessary air changes (m^3/h fresh air). National standards define the requirements for levels of fresh air supply in order to achieve a satisfying indoor climate.

In some countries the requirements for the thermal indoor climate are different depending on whether natural or mechanical ventilation strategies are used. Recent research has shown that with natural ventilation strategies there is a tendency for behavioural and psychological adaptation, which allows for broader limits while still achieving an acceptable indoor climate.

If hospitals can guarantee high quality thermal indoor climates, they will improve the staff efficiency, reduce the number of sick days and improve the chances for patients to rehabilitate and be discharged.

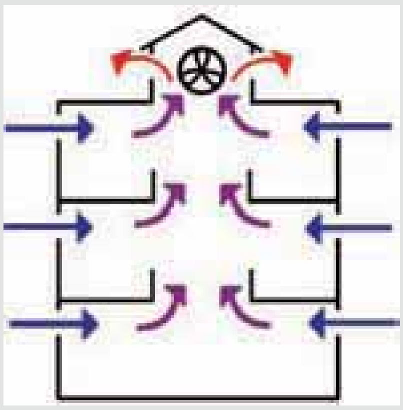
*Visualisation of atrium in **Fachkrankenhaus Nord-friesland** (Germany)*

Examples of simulation tools for thermal indoor climate analysis:
- ***TRNSYS***
- ***BSim2000***
- ***ESP-r***
- ***TAS***

Ventilation strategies

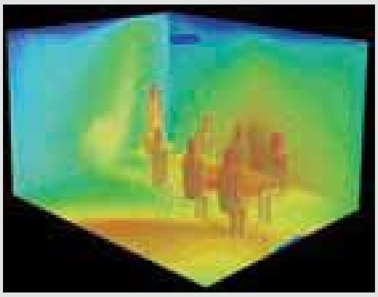
There are several ventilation strategies, such as natural, mechanical or hybrid ventilation, all of which offer the potential for heat recovery or solar pre-heating of the incoming outdoor air. In hospital buildings there are departments with certain restrictions for air renewal and room temperature, i.e. kitchens, operating theatres, laboratories, departments with risks of infectious diseases etc. In such areas, balanced mechanical ventilation systems are recommended, in which the air change route, the relative humidity (RH) and air filtering are specified.

In other areas, for example bed wards or day rooms, other ventilation strategies could be considered, depending on the results of the analysis of the thermal indoor climate. **Natural ventilation** is a ventilation method where the energy demand for ventilation is either very small or zero. In principle, fresh air enters the building through inlet openings (cracks, throttles, valves, windows), and the "used" air departs from the building through discharge openings (windows, skylights, cowls). The airflow is driven by thermal and dynamic buoyancy effects. The thermal buoyancy effect arises from the temperature difference between outdoor and indoor temperatures, whereas the dynamic buoyancy effect evolves from the exterior wind pressure on the building.



The principle of hybrid ventilation

Hybrid ventilation is fan-assisted natural ventilation. In other words, the general ventilation strategy chosen is natural ventilation, which in



Advanced tools for natural ventilation (Airpak by Fluent)

Examples of simple simulation tools for airflow analysis:
- ***Contamw***
- ***COMIS***

Examples of advanced simulation tools for airflow analysis:
- ***ESP-r***
- ***TRNSYS***
- ***CFD (Airpak, Flowvent, Star CD)***

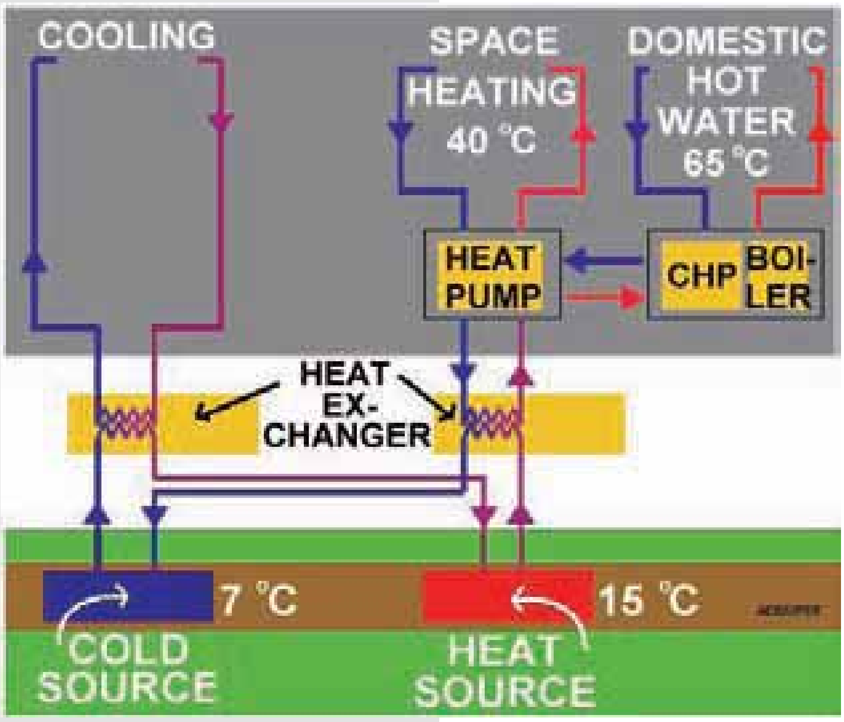
extreme situations is assisted by mechanical fans. Extreme situations could arise from very small buoyancy effects, i.e. minimal temperature differences and/or no wind load, which may appear for short periods of time during the year, depending on the local meteorological weather conditions.

If natural ventilation is chosen as the general ventilation strategy for a specific department in a hospital building, it is necessary to perform an airflow analysis in order to determine the size of the necessary inlet and outlet opening areas. The airflow analysis would also be used to confirm that the chosen ventilation strategy complies with the requirements for the indoor climate determined from the thermal indoor climate analysis.

Airflow analysis can be performed by simple simulation tools, based on multi-zone models, to define the inlet and outlet area sizes needed to meet the demands for air renewal. In some building projects, where the actual building is very complex and there may be a risk of draught or high indoor temperatures, a more detailed airflow analysis may be required, these can be performed using computational fluid dynamics (CFD).

Using natural or hybrid ventilation as the primary ventilation strategy can reduce the energy demand for ventilation purposes significantly, without compromising the quality of the indoor climate. If patients in a hospital are aware that the environmental aspects of the hospital are highly prioritised, and that sustainable development is being supported with use of natural ventilation, the users of the building are most likely to experience a healthy hospital building, where patients have good chances for fast recovery.

Cooling



Visualisation of aquifer at ***Deventer Hospital*** *(the Netherlands) used for heating during winter and cooling during summer*

In some sections of a hospital building cooling may be necessary, but wherever possible other strategies should be considered first, since cooling typically contributes significantly to the overall energy demand.

In some building projects, cooling issues are discussed even before deciding the structure of the building, which implies inefficient use of the possible passive performance of the building.

Defining cooling during the very last step of energy integrated design allows for efficient use of the passive performance and may reduce or entirely remove the need for cooling.

Examples
of innovative elements
from HOSPITALS using energy conscious designs

Double skin facades

A double skin facade acts as an additional external layer, which creates external (thermal and sound) insulation and solar protection for the building. Double skin facades increase the potential for saving energy, as they reduce heat loss through the building envelope and allow for preheating of ventilation air, or infiltration air, in the double skin facade.

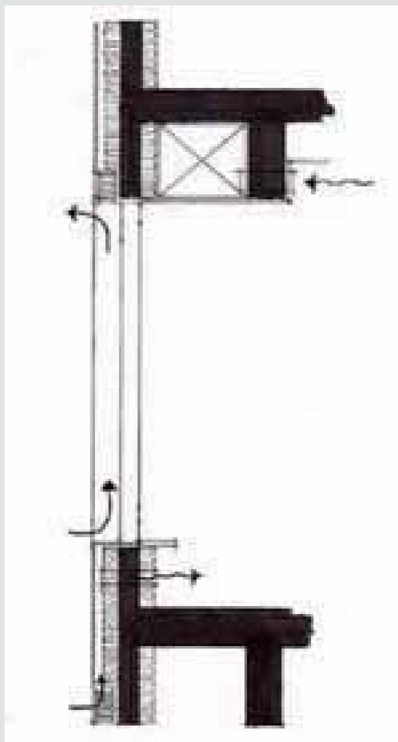
Double skin facades can be used in a great variety of applications, they make building construction simple and easy to assemble. Daylight can penetrate through the facade effectively and provide good views out. For a patient in a bed ward in a hospital this can give an impression of openness and transparency to the outside world while still giving protection against noise.

The cavity of a double skin facade provides a number of benefits; an effective, inexpensive solar shading system may be built into the cavity and a naturally driven night cooling strategy can be used, while still keeping the building safe from burglary. However, night cooling would primarily be used for office areas, not bed-wards.

In order to improve the well-being of the patients it is important to provide light and pleasant surroundings, with plenty of daylight and high thermal comfort levels. The use of double skin facades offers a positive contribution towards this.

In the HOSPITALS project, double skin facades are planned for in the new-build part of Aabenraa Hospital (Denmark), in Fachkrankenhaus Nordfriesland (Germany) and in Meyer Children's Hospital (Italy).

Double skin facade



Schematic drawing of a double skin facade

Insulation

The HOSPITALS project looked at transparent insulation and ’environmentally friendly’ insulation materials as well as conventional insulation materials. Many conventional insulation materials can cause environmental problems, such as destruction of the environment during raw material extraction, consumption of limited natural resources and large energy demands during manufacture.

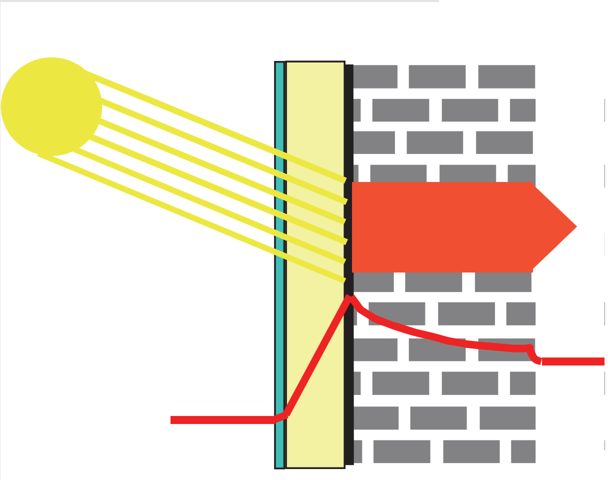
Facade at ***Torun City Hospital*** *(Poland)*

"Environmentally friendly" insulation materials are made from renewable plant or animal sources, which minimise the impact on the environment during the harvesting of the raw materials. Such materials have low embodied energy, contain no toxic or synthetic chemicals and are fully biodegradable.

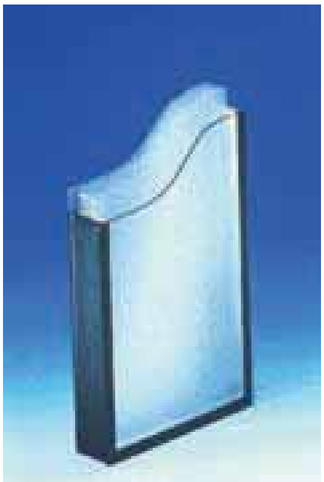
Transparent insulation allows improvements in the physiological conditions of the building and the indoor comfort of the patients, regarding daylight and heating. There are two main methods for the use of transparent insulation:

- As transparent glazing offering access to daylight with low heat losses
- As a highly insulating cover layer for solar mass walls.

By using transparent insulation in large windows, good daylight access conditions are provided without risking high heat losses through the windows and at the same time the need for electricity for artificial lighting is reduced.



The principle of the Solar Mass Wall at ***Fachkrankenhaus Nordfriesland*** *(Germany) (FISE)*



Transparent insulation from Okalux, (49 mm).
U = 0,8 W/m°K,
g_{dir} *= 80%,* g_{dif} *= 60%*

By installing transparent insulation on the outside of a thermally heavy wall, the wall will be heated and provide heat to the adjacent room, with the wall acting as a low temperature radiator. This gives greater comfort to the patients and reduces the need for radiators.

Reducing the need for metal radiators has been an important issue for Fachkrankenhaus Nordfriesland (Germany). This hospital also treats patients who are allergic to electromagnetism, so the use of metal must be minimised. Transparent insulation was planned for on the south facing facades at Fachkrankenhaus Nordfriesland.

Multi-functional PV systems

Multi-functional PV system from Kollektivhuset in Copenhagen (Denmark)

Photovoltaic (PV) systems are power systems which convert sunlight directly into electricity. PV systems can be installed on vertical surfaces, for example glazed areas, where they can work as a solar shading device while still effectively produce electricity - these are called multi-functional PV systems.

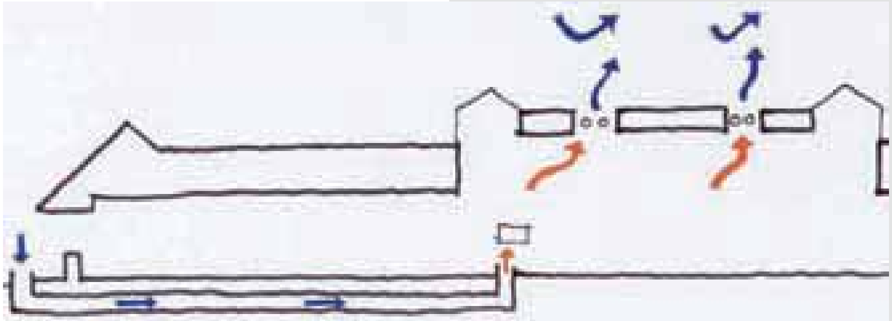
The design team at Fachkrankenhaus Nordfriesland (Germany) designed a transparent glass roof as a common entry and recreation area between two treatment areas. A multi-functional PV system was planned for this roof.

A multi-functional PV system will also be used in the recreation and entry area of MEYER Children's Hospital (Italy).

Hybrid ventilation

Fan-assisted natural ventilation, also called hybrid ventilation, is a combination of natural and mechanical ventilation. Hybrid ventilation utilises the natural buoyancy effects of external wind pressure and temperature differences between indoor and outdoor temperatures.

In extreme situations, for example almost no temperature difference between outside and inside and no wind, it may be necessary to supplement the system with mechanical fans in order to create the necessary pressure difference between inlet and outlet openings. Hybrid ventilation is an energy saving ventilation method as it utilises natural buoyancy effects with minimal electricity demand.



*Drawing of the principle of hybrid ventilation in a glazed courtyard at **Aabenraa Hospital** (Denmark)*

In Aabenraa Hospital (Denmark), hybrid ventilation is the chosen ventilation strategy for selected sections, i.e. common and patient recreation areas in the glazed courtyards and in selected offices and treatment areas. For the glazed courtyards, the ventilation system will operate as displacement ventilation, with fresh air passing through the basement in large closed channels, at a constant temperature of about 16°C providing cooling in summer and preheating in winter. When necessary, comfort heating is provided as the fresh air passes through convectors before entering the indoor areas. The low air pressure in the channels means that dust filters may be used without causing too high pressure resistances. Supplementary ventilation can be provided directly through throttle valves in the façade. Air is exhausted through roof integrated wind cowls, as the wind will create sufficient low-pressure in the system to ensure air changes in the glazed courtyard of 1,0-1,5 ach^{-1}. The roof integrated wind cowls are equipped with a small back-up ventilator to provide sufficient ventilation levels in periods where the wind is not sufficient. Hybrid ventilation was also planned for Meyer Children's Hospital (Italy) and Fachkrankenhaus Nordfriesland (Germany).

*Roof integrated wind cowls at **Aabenraa Hospital***

Building materials

In hospital buildings, careful selection of building materials is necessary, as these are exposed to the indoor climate and have a significant impact on the air quality. Utilisation of healthy building materials with minimal degassing can reduce the ventilation requirements and still provide the patients with a satisfying and healthy indoor climate.

In Fachkrankenhaus Nordfriesland (Germany) selection of building materials and other components has been considered carefully, in order to minimize the potential impact on the patients' well-being. The choice of building materials has been based on the following criteria:

- emission
- adsorption
- surface roughness
- cleaning

Furthermore there is no use of PVC-materials and a minimal use of metals.

Building materials

Optimised control systems

Building Energy Management Systems and controls (BEMS) include a variety of systems to control, monitor and optimise various functions and services provided in a building including; heating, cooling, ventilation, lighting and the management of electric appliances.

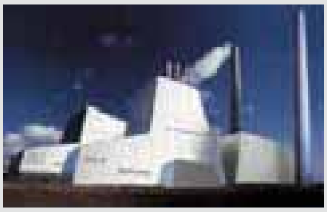
*BEMS unit at **Aabenraa Hospital** (Denmark)*

The energy crisis in the 1970's led to the development of simple BEMS in the 1980's, mainly for the residential and services sectors. Today a BEMS is a complex device with multi-functional purposes where a central unit works as a "managing supervisor" of the building performance.

BEMS are necessary for the correct function of hybrid ventilation systems where detectors for CO_2 and temperature controls manage the throttle valves in order to minimise heat losses through ventilation openings.

Immediate alarms, generated by the system, allow fast reactions by the maintenance department when mechanical defects occur. Thus, excess energy use arising from defective pumps, valves, dampers etc. can be eliminated.

Advanced BMS will be used in Aabenraa Hospital (Denmark), Meyer Children's Hospital (Italy) and Deventer Hospital (the Netherlands).



*The CHP plant **Avedøre 2** in Denmark*

Combined heat and power plants

Combined heat and power plants (CHP) are technologies for simultaneous generation of heat and power. The heat generated is utilised via suitable heat recovery equipment for a variety of purposes, including industrial processes, community heating and space heating.

*The CHP plant **Fynsværket** in Denmark (Elsam kraft)*

As electricity is generated on site, transmission losses can be avoided. This contributes to the fact that a CHP plant typically achieves a 35% reduction in primary energy usage, compared with power stations and heating boilers. Besides the economic savings, new CHP installations can contribute to reductions of up to 50% in CO_2 emissions, in comparison with generation from coal-fired power stations.

In many cases, heat generated from CHP plants is to some extent a "waste product" for which reason such a heating energy supply may be very competitive compared to other heat production systems.

In Fachkrankenhaus Nordfriesland (Germany), a CHP plant in connection with a natural gas boiler is planned. Such small systems are of particular interest in areas with no central district heating system, especially as these systems may often use various kinds of biomass fuels.

Examples of European hospitals

using energy conscious designs

In the following pages five examples of energy conscious designs will be presented. For more detailed information of the individual projects and for final technical reports please go to the HOSPITALS web site www.eu-hospitals.net (section "Results")

Also, more detailed individual project brochures have been developed for each of the five demonstration projects. These can also be downloaded from the HOSPITALS website.

Aabenraa+Haderslev Hospital (Denmark)

Aabenraa Hospital is a medium sized hospital (gross area 27,650 m^2 with 104 beds), which was erected in 1987-1992 in the southern part of Jutland in Denmark. In 2002, the health committee of the County of South Jutland made a decision in principle to enlarge the existing hospital by about 10,000 m^2, divided into 2 phases, increasing the number of beds to 258.

Detailed valuable studies of double skin facades and hybrid ventilation were originally carried out for Haderslev Hospital within the HOSPITALS project. However, for political reasons this hospital is not being renovated and it was replaced by Aabenraa Hospital within the HOSPITALS project.

Innovative elements in Aabenraa Hospital:

- Building integrated solar energy
- Double skin facades
- Active solar energy for domestic hot water
- Effective heating supply system and convectors for comfort heating in areas with hybrid ventilation
- Hybrid ventilation
- Computerised Building Energy Management System (BEMS) used for regulation of the hybrid ventilation system (draught and temperature control) including comprehensive monitoring

Innovative elements in Haderslev Hospital:

- Double Skin Facades
- Hybrid ventilation
- Active solar for heating of hot water
- Conversion from a steam based to a water based heating system
- Conversion of existing air heating system to water based system
- Installation of a modern BEMS

Aabenraa Hospital

Expectations

32% reduction of energy demand for heating and cooling

3% reduction of energy demand for electricity

20% reduction in CO_2 emissions

Haderslev Hospital

Fachkrankenhaus Nordfriesland

Expectations

41% reduction of energy demand for heating and cooling

57% reduction of energy demand for electricity

46% reduction of CO_2 emissions

Meyer Children's Hospital

Expectations

36% reduction of energy demand for heating and cooling

35% reduction of energy demand for electricity

36% reduction of CO_2 emissions

Fachkrankenhaus Nordfriesland (Germany)

Fachkrankenhaus Nordfriesland (FNF) is a medium sized hospital (gross area of 5,800 m^2 and 120 beds) situated in the city of Bredstedt in Germany, near the North Sea. It was founded in 1975 as a non-profit making public hospital owned by a private foundation and has specialized in psychiatry, and psychosomatic and environmental medicine.

The new building will enable the hospital to offer different areas for patients and employees and double the capacity of the hospital. Furthermore, it will allow advanced medical research projects to be carried out.

Innovative elements:

- Improved insulation levels
- Double skin facades
- Multifunctional PV system integrated in the glass roof
- Transparent insulation
- Low-emission and low-adsorption building materials
- New local CHP plant
- Atrium / buffer space for recreation

Meyer Children's Hospital (Italy)

The Meyer Children's Hospital is a medium sized hospital (gross area of 31,000 m^2 and 150 beds) situated in Florence in Italy. The hospital will be one of the most important in the paediatric field in Italy and in Europe.

The planning and design of the healthcare environment, including the psychological effects of the environment, was the primary focus of the project. This approach was considered essential for the neonatal intensive care environment which has significant effects on babies, their families and caretakers. Special attention was paid to interior rooms and the surrounding view in order to give the best possible confinement period and to stimulate beneficial effects on patient health.

Innovative elements:

- Buffer space (greenhouse/conservatory)
- Energy efficient, partly natural, ventilation system
- Light ducts
- Environmentally friendly surface paints
- Building Management System
- Multi-functional PV systems

Torun City Hospital (Poland)

Torun City Hospital is a large hospital (gross area 35,000 m^2 and 249 beds) situated in Torun in Poland. The building project includes renovation as well as new buildings. Torun city is part of the European Network of Healthy Cities, where health promotion at a local level is based on the prohealth activity strategies of the "Healthy Cities" project of the World Health Organisation (WHO).

Innovative elements:

- New room temperature controls
- Modern heaters
- Optimised ducting (decreasing duct diameters for the central heating)
- Advanced valves (including the heating system)
- Natural ventilation
- New high performance wood framed windows
- Significant increase in the insulation level (roofs, windows, walls)

Torun City Hospital

28% reduction of energy demand for heating and cooling

26% reduction of CO_2 emissions

(reduction of energy demand for electricity is not included in the project)

Deventer Hospital (Netherlands)

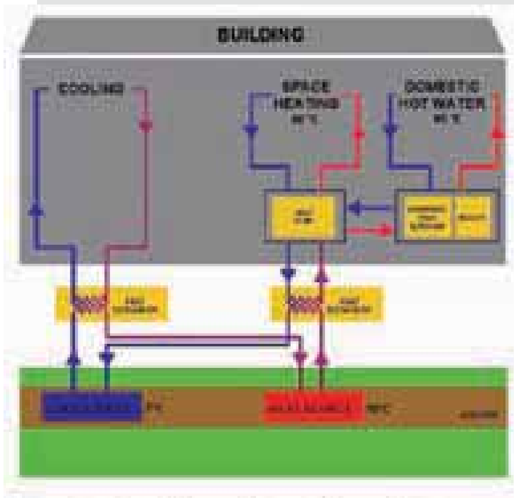
Deventer Hospital is a large hospital (gross area 65,000 m^2 and 380 beds) situated in Deventer in the Netherlands. The number of beds has been reduced from 430 beds in the old hospital, with the aim of treating as many patients as possible in day care.
The Dutch Care Federation (Nederlandse Zorgfederatie) signed an agreement with the Dutch Department for Economy to reduce the energy for space heating, ventilation, cooling and electricity by 30% - the newly built Deventer Hospital offers a chance to implement this plan.

In addition to a strong focus on energy efficiency, the new building design is strongly dedicated to the comfort and well-being of the patients, employees and other user-groups.

Innovative elements:

- Proper building envelope insulation, low-E glazing and heat recovery from ventilation air
- Design of floors and departments to group together areas with similar use periods
- Heat pump connected to seasonal storage of heat and cold in aquifers
- Combined heat and power for domestic hot water production
- Flexibility in energy management and building organisation through all-air heating and ventilation system
- Building Energy Management System

Deventer Hospital



Schematic principle of aquifer

57% reduction of energy demand for heating and cooling

13% reduction of energy demand for electricity

55% reduction of CO_2 emissions

Check list

for implementation of Integrated Energy Design

In order to facilitate the use of the Integrated Energy Design Process during the design of a specific building, the following pages sum up the Design Handbook in the form of a checklist.

The checklist provides a number of questions to help the client, the architect, the engineer and everyone else involved in the design process identify and specify the key design parameters at the right time in the process. The questions are divided into three types:

- ☐ General Questions, these primarily help the client and the end-users of the building to be clear about the desired function, flexibility, special requirements etc.
- ☐ Topic Specific Questions, focusing on single steps in the Integrated Energy Design Process and how to deal with these.
- ☐ Control Questions, these pin-point the most critical parameters in the design of the building and can be used to check whether or not all the major issues have been sufficiently developed and clarified.

Like the checklists in an aircraft; they assist the pilot but they do not replace the pilot. The best design companion in the process of Integrated Energy Design is dialogue within the team from day one and careful use of various design software and tools able to simulate the dynamic thermal performance and properties of buildings.

In many practical design situations the design team is hesitant to introduce advanced tools in the early phases of a design. In the traditional design process, the design team waits and only uses advanced tools at the end of the process in order to verify the function of the design and to provide the documentation required in the design brief. However, when undertaking an Integrated Energy Design Process, understanding the dynamics, especially the thermal dynamics, of the building can be the key to choosing the correct energy design strategy for the building. Advanced simulation programs can also provide data for the more traditional elements of the design, e.g. dimensioning the heating demand to determine the number and type of radiators or convectors.

When using simulation software the results are no better than the input used for the simulations. In the early design phase, knowledge of the building is very limited, but dynamic tools can still be very useful because they can provide important information on the sensitivity of the performance of the building to changing key design parameters, such as the glazing ratio, internal heat loads, thermal mass, ventilation strategy etc. For the clients and the users of the building these analyses can provide valuable information when deciding density, location of functions, facade designs etc.

On the following pages the details of the checklist are provided To read more on the progress and results of the design of sustainable hospitals and health care buildings, you may visit the HOSPITALS project web-site at:

http://www.eu-hospitals.net.

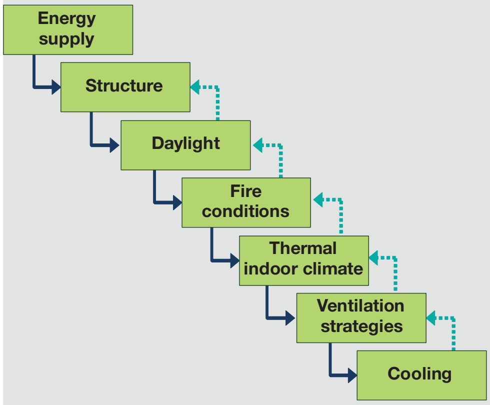
General questions

The questions below are important to raise and discuss at the earliest stages of the design phase. These questions help the design team and the client to agree on the general goals, priorities and cost criteria:

☐ What are the key criteria to judge the success of the project?
☐ How does the client value and compare investments and savings in running costs?
☐ What criteria should be used to judge the indoor climate and flexibility aspects for various design proposals?
☐ What is the decision making route and what does each level require as a basis for making a decision?
☐ What could encourage energy conscious behaviour in the buildings by the client, the staff and the users?
☐ What is likely to be the long term running conditions of the building
  ☐ how does this affect the current design?
☐ What are the most important risks the project could face during design, construction and operation?
☐ Does everybody understand all implications of the design brief. Where is the brief felt to be most weak? - how could it be strengthened or clarified?

CABE's
The Value of Good Design,
quotes a 21% improvement in hospital discharge rate from a hospital renovation, effectively reducing total costs by 21%. It improved care quality, speed, satisfaction and had spin-off benefits of lower drug use, reduced return visits and other factors
Ref.: REFOCUS, November/December 2005.

Specific Questions on each topic



The topics below refer to topics in the Integrated Energy Design Process introduced on page 9. In general, the questions are broad in order to help the design team see the design process from a more holistic point of view than what is usually practiced in traditional design work.

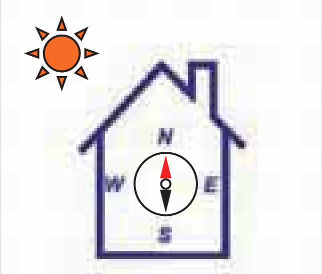
Topic 1 - Energy supply:

☐ What is the present energy supply situation in the area, to the complex and to the specific buildings?
☐ Is this expected to change in the lifetime of the building?
☐ What would be the benefits of planning for a changed situation and not the current? - Who is to take the long term decisions?
☐ What renewable energy resources could be exploited?

Topic 1 - Energy supply

Topic 2 - Structure:

☐ What is the infrastructure around the building (transport, energy supply, noise, smell, wind, shading, micro-climate, etc.)? How could this influence the design?
☐ What are the possibilities and limitations regarding orientation of the facades of the building?
☐ What principal connections have to be established between the different functions? - Which are tightly connected, which are flexible?
☐ Is it possible to group together functions with similar indoor climate needs (daylighting, temperature, ventilation, patterns of use etc.)?
☐ How do these groups interact with the general logistics of the hospital or health care facility? - synergies and/or conflicts?
☐ Are there major m&e services or supplies already in the building which have to be linked to? - what would it take to change this?



Topic 2 - Structure

Topic 3 - Daylight:

Topic 3 - Daylight

- ☐ Which functions could benefit from daylighting (besides all common areas accessible to users)? Could glare and the risk of too much daylight be overcome with flexible glare protection?
- ☐ Does the selected glazing provide good daylighting conditions (size, light transmission, U-value, G-factor etc.)?
- ☐ Has all artificial lighting control in daylit areas been adequately zoned and designed for dimming according to the availability of daylight?
- ☐ Are daylighting simulations co-ordinated with the electrical calculations for the lay-out of artificial lighting and controls?
- ☐ What is the maximum energy saving potential from artificial lighting and how sensitive is the saving and pay-back time to changes in electricity prices over the lifetime of the building?
- ☐ Are maintenance issues taken into account in the economic evaluation of various solutions for artificial lighting (the cost of replacing bulbs, cleaning open light fixtures etc.)
- ☐ Does the artificial lighting solution have an impact on the amount of waste (used bulbs, fluorescent lamps etc.)

Topic 4 - Fire conditions:

Topic 4 - Fire conditions

- ☐ Could a differentiated fire protection strategy be applied (sprinkling, warning, smoke ventilation etc.)?
- ☐ Would a differentiated strategy provide options for natural ventilation?
- ☐ Could smoke ventilation openings also be used for natural ventilation?
- ☐ Are there any special standards for the systems which should be followed (specified by local authorities, insurance companies etc.)?

Topic 5 - Thermal indoor climate:

Topic 5 - Thermal indoor climate

- ☐ Which patterns of use must the building be designed for?
- ☐ Do activity levels and type of clothing vary in the buildings and does this variation also demand different conditions in different parts of the buildings?
- ☐ What is the desired and specified comfort level in various zones of the building and how should this be demonstrated (simulations, mock-ups, test rooms etc.) during the design phase?
- ☐ Can internal heat loads be reduced, or utilised to contribute to a good thermal indoor climate?
- ☐ In offices: what types of PC screens will be used now and planned for the long term (traditional versus flat screen - internal heat gains)
- ☐ Could solar gains be reduced/utilised and still offer a building with good daylighting conditions?
- ☐ Could the use of exposed thermal mass for evening out temperature fluctuations be utilised in various zones of the building?
- ☐ Do the analyses and parametric studies carried out provide sufficient information on the need for air exchange, fresh air supply, temperatures and air speed during the day and seasons?
- ☐ Has sufficient consideration been taken of principal types of ventilation (displacement, comfort zones, room heights etc.?)
- ☐ Is low temperature heating planned to provide options for the use of solar energy or waste heat produced? How does this influence controls, possibilities for variations and flexibility of use?
- ☐ If cooling is considered as an option to reduce high temperatures, are there any alternatives with equal benefits in temperature reduction?

Topic 6 - Ventilation strategies:

- ☐ Is the building benefiting from the prevailing wind directions to help the natural ventilation of the building?
- ☐ Are rooms designed to use natural ventilation if relevant (high rooms, openings, cleaning conditions, filters with low pressure drop etc.)
- ☐ Could natural and mechanical ventilation be combined?
- ☐ Are zones with the same demand patterns supplied from the same plants?
- ☐ Could a decentralised lay-out better match variations in demands from the various functions and buildings?

Topic 7 - Cooling:

- ☐ Are there natural sources for cooling available? (sea water, ground water, night time cooling, solar assisted systems?)
- ☐ Could cooling load be avoided by changing density, glazing, thermal mass controls etc.?
- ☐ What would be the saving in total costs if cooling could be completely omitted? Could this saving finance alternative design solutions?

Control Questions

- ☐ What restrictions on the design have been agreed?
- ☐ Are these restrictions sufficiently specific to be of real guidance to the whole design team, i.e. more specific than just stating “economic”, “good indoor climate”, “flexible” etc.
- ☐ What could happen that would allow changes in these restrictions?
- ☐ Does the design fulfil the targets in the European Commission Directive on the Energy Performance of Buildings? - who in the design team is responsible for checking this?
- ☐ Has a motivator of the integrated process been identified?
- ☐ Has the mandate of the motivator been openly discussed and agreed between the design team, the client, the investors, municipalities, politicians etc.?
- ☐ Has a good information and communication strategy been set up, with plans on when to involve who and what different stakeholders should be prepared to contribute to the different phases of the design?
- ☐ Is the design process truly interdisciplinary or are some members passive in the early phase? What could be changed to get these actors involved?

Not all simple solutions are right solutions — but the right solutions are always simple.
Heinrich Tessenau
German Architect (1876-1950)

Please note that the above list is based on the experience and recommendations of the members of the Hospital project. The list is not designed to be complete or to replace any other standard quality documentation material of a specific site, but should be used purely for guidance and inspiration of the design team.

The design of hospitals and health care buildings is constantly changing and developing. If you would like to share your experiences, your recommendations, additions to the checklist etc., your comments and contributions are more than welcome,

- ☐ *see the HOSPITALS project website for further details:*
  http://www.eu-hospitals.net

ADMINISTRATIVE AND FINANCIAL COORDINATOR
Liane Timm Schwarz,
The County of South Jutland
Skelbækvej 2
DK-6200 Aabenraa, Denmark
Tel.: +45 74 33 50 50
e-mail: liane_schwarz@sja.dk
www.sja.dk

SCIENTIFIC AND TECHNICAL COORDINATOR
Olaf Bruun Jørgensen, Esbensen Consultants A/S
Carl Jacobsens Vej 25 D
2500 Valby, Denmark
Tel.: +45 33 26 73 02
e-mail: o.b.joergensen@esbensen.dk
www.esbensen.dk

WP1 INTEGRATED DESIGN PROCESS
Olaf Bruun Jørgensen, Esbensen Consultants A/S

WP2 EUROPEAN DESIGN WORKSHOPS
Olaf Bruun Jørgensen, Esbensen Consultants A/S

Gert Johannesen, S&I Architects A/S
Buchwaldsgade 35
DK-5000 Odense C, Denmark
Tel.: +45 66 11 59 11
e-mail: gj@sogi.dk
www.sogi.dk

Chiel Boonstra, DHV Building and Industry
P.O. Box 80007, NL-5600 JZ, Eindhoven
The Netherlands
Tel.: +31 40 250 9216
e-mail: chiel.boonstra@dhv.nl
www.dhv.nl

Marco Sala, Marco Sala Associates
Via Pippo Spano 15
I-50129 Firenze, Italy
Tel.: +39 055 5048394
e-mail: marco_sala@unifi.it

WP3 MONITORING AND EVALUATION
Christel Russ
Fraunhofer Institut for Solare Energy Systems
Heidenhofstr. 2, DE-79110 Freiburg
Tel.: +49 761 458 8512
e-mail: christel.russ@ise.fhg.de

WP4 FACILITIES MANAGEMENT & PHYSICAL WORKING CONDITIONS
Cees van Mil, Deventer Hospital
Chiel Boonstra, DHV Building and Industry
Eberhard Schwarz,
Fachkrankenhaus Nordfriesland

WP5 DISSEMINATION
Olaf Bruun Jørgensen, Esbensen Consultants A/S
Renato Colombo, Meyer Children Hospital
Roman Nadolny, Torun City Hospital

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The five hospital sites are:

AABENRAA HOSPITAL, DENMARK
Liane Timm Schwarz, The County of South Jutland
Esbensen Consultants A/S (Energy consultant)
S&I Architects A/S (Architect)

FACHKRANKENHAUS NORDFRIESLAND, GERMANY
S nke Thiesen / Eberhard Schwarz
Krankenhausweg 3
DE-25821 Bredstedt, Germany
Tel.: +49 4671 90 4-0
e-mail: sabine.mueseler@fachkrankenhausnf.de
Esbensen Consultants A/S (Energy consultant)
Detlefsen + Lundelius (Architect)

MEYER CHILDREN's HOSPITAL, ITALY
Renato Colombo
Via Luca Giordano, 7 M
I-50132 Firenze, Italy
Tel.: +39 055 5662319
e-mail: DirAz@Meyer.it
www.meyer.it
Marco Sala Associates (Energy consultant)
CSPE (Architects)

TORUN CITY HOSPITAL, POLAND
Krystyna Zaleska, Roman Nadolny
Specjalistyczny Szpital Miejski, im. M. Kopernika w Toruniu
ul. Batorego 17/19
87-100 Torun, Poland
Tel.: +48 56 610 0324
e-mail: rom@med.torun.pl

DEVENTER HOSPITAL, THE NETHERLANDS
Cees van Mil
PO Box 5001, Ceintuurbaan 6
NL-7400 GC Deventer, The Netherlands
Tel.: +31 570 64 6528
e-mail: CJHM.vanMil@dz.nl

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