Ingeniørhøjskolen I København

European Project Semester
Spring Semester 2010

A LOW ENERGY HOUSE

Group 2

Members:

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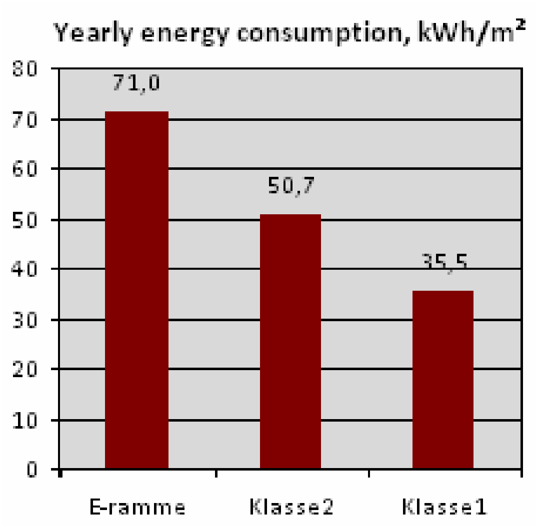
Abstract

CENERGIA is a consulting engineering company, established in 1982 by four employees at the Thermal Insulation Laboratory at the Technical University of Denmark (now: byg.dtu).

EPS students of the IHK were asked to design a low energy house. This gives the company a fresh insight into a low energy house design from the mixed students. This year 48 students applied for the EPS program, making twelve mixed teams, 2 teams designing a low energy house.

At the beginning, a brief was given to direct the project in accordance with the CENERGIA criteria's. All teams had to work freely and organise themselves. The aim of this project is designing a low energy house which have to reach Class 1 (Danish standard class when house use less than 35.5 kWh/m2 per year).



ASCOT program from company CENERGIA

Our project plan:

Project review: February 24th
Interim report March 19th
Project review 2: February 24th
Final report: June 3th
Exam: June 16th

At the end of the semester and with the help of EPS teachers, both team had developed a low energy house project for the CENERGIA.

Contents

1. Introduction

The team is composed of four students from different countries but we all have followed the same course in the IHK (Copenhagen University college of Engineering) during the 2010 spring semester. This course is the EPS (European project Semester) program for exchange students. This program is composed of different theoretical courses and a project.

This report compiles all the information relating about the team project.

1.1. Work team

Student	Nationality	School
Oskars Pudžs	Latvian	LLU
Leo Caumeil	French	IUT de saint-etienne
Andres Rubio Hernandez	Spanish	EPSEVG
Sylvain Robic	French	IUT de Cholet

1.2. Brief of the project

At the beginning, a brief was given to direct the project in accordance with CENERGIA criteria.

It defines the problem and gives the objectives to fulfil.

Assignment: Design a low energy house

Client: CENERGIA

Scope: CENERGIA plans to design a low energy house in Denmark, Copenhagen

Design requirements for a low energy house:

Must:

- Effective lighting
- Electric control system
- Effective ventilation system
- Effective heating system control
- Effective building thermal isolation
- Use sun energy (Solar photovoltaic panel, solar capture, use daylighting)

Nice to have:

- Use wind energy
- Use garbage energy (electricity/heat generator from biomass)

Project plan:

Project review: February 24th

Interim report March 19th

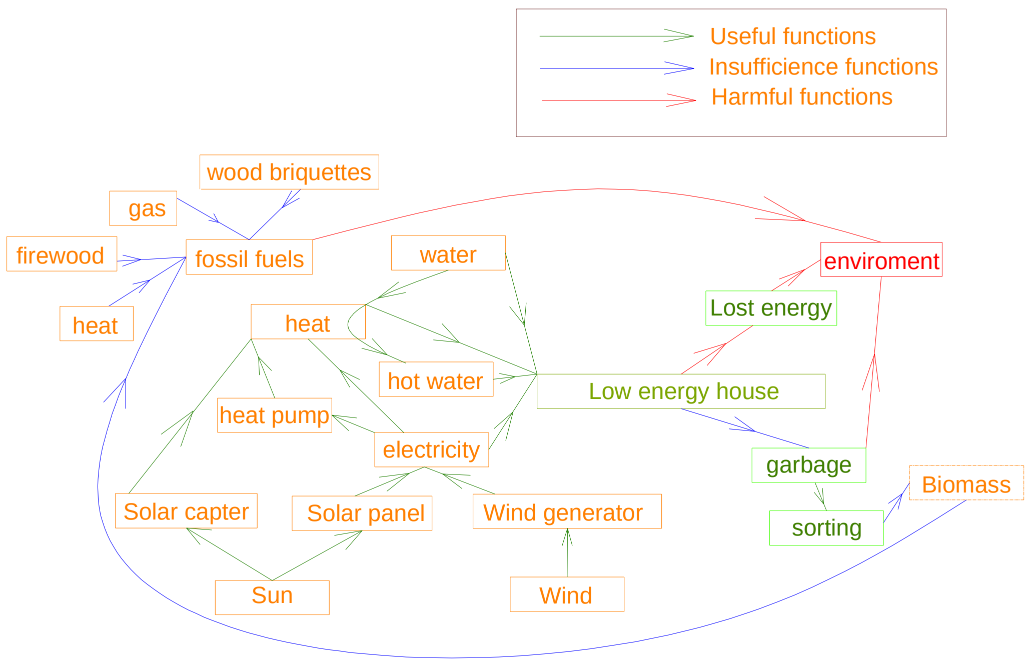
Project review 2: April 8th

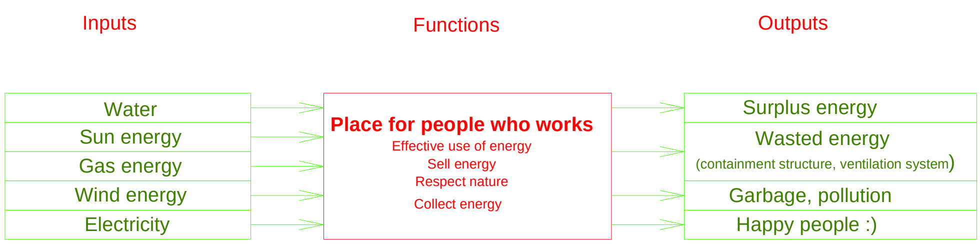
Final report: June 3rd

Exam: June 14+15+16th

2. Methodology

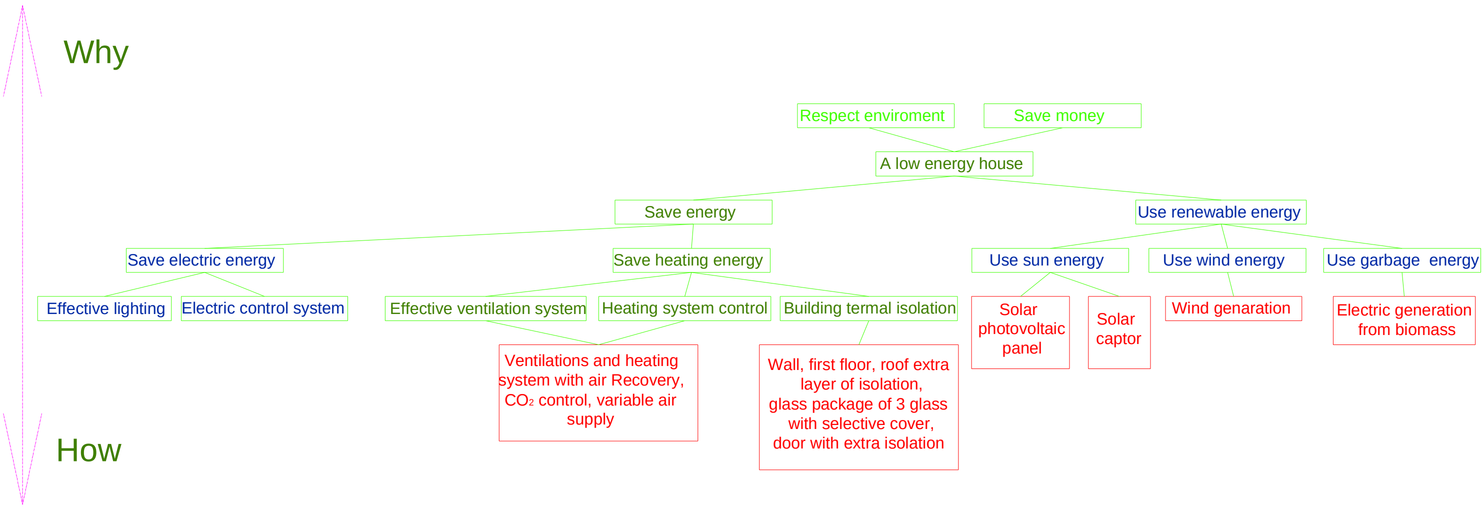
2.1. Product functional model "A low energy house"





2.2. Clarifying objectives

2.2.1. Developing levels of objective "Low energy house"



2.3. Task

2.3.1. Save energy

- Save electric energy
  - Effective lighting
  - Electric control system
- Save heating energy
  - Effective ventilation system
  - Heating system control
    - (Ventilation and heating system with air recovery CO2 control, variable air supply)
  - Building thermal isolation
    - Wall first floor, roof extra layer of thermal isolation, glass package of 3 glass with selective cover, door with extra isolation

2.3.2. Use renewable energy

- Use sun energy
  - Solar photovoltaic panel for electricity generation
  - Solar capture for hot water
- Use wind energy
  - Small wind generator for electricity generation

2.4. **Responsibility matrix**

WBS \ OBS	Leo	Oskars	Andres	Sylvain
Effective lighting			S	R
Electric control system		S	R	
Effective ventilation system (Ventilation and heating system with air recovery, variable air supply)		S	R	
Solar photovoltaic panel for electricity generation				R
Building thermal isolation Wall first floor, roof extra layer of thermal isolation, glass package of 3 glass with selective cover, door with extra isolation	R	S		
Solar Collector system for hot water preparation and heating system		R		
Calculate energy flow in 1 year	S	R	S	S

3. Desk research

When starting a project, the first thing to do is to gather as much existing information as possible. That is the aim of the “desk research”. Information can be taken from every existing source.

3.1. Cenergia

CENERGIA ENERGY CONSULTANTS

CENERGIA is a consulting engineering company, established in 1982 by four employees at the Thermal Insulation Laboratory at the Technical University of Denmark (now: byg.dtu). They work for sustainability in building through participation in national and international cooperation projects that:

- demonstrate new knowledge of energy savings and utilisation of renewable energy in building projects, e.g. in urban ecological projects;
- develop energy saving, sustainable technologies further and put these into practise;
- develop calculation tools for application by design and total economic optimisation of housing projects;
- provide and communicate new knowledge of sustainable building.

Their activities span initiation, planning and evaluation of demonstration projects, contribution to process and product development via energy planning and project management of international cooperation projects within these fields.

In Denmark, CENERGIA co-operates with housing associations, local authorities, architects and other consulting engineering companies, suppliers, contractors, the Danish Building Research Institute, the Technical University of Denmark and the Danish Technological Institute. In addition to this we co-operate with an extensive international network of institutes and consultants.

Total economic optimisation

Preparation of a general concept of a new build or retrofit housing project based on a total economic optimisation of all possible energy saving technologies. The total economic optimisation is based on local parameters, heating, gas, electricity and water prices. The result - an economic prioritisation of all technologies - is used as base for composition of a concept that gives optimum energy savings without an increase of the rent for the tenants. CENERGIA has developed a special computer tool, Optibuild, for total economic optimisation.

Solar energy - solar heating, PV-modules and passive solar heating CENERGIA's employees have more than twenty years' experience of development, test, planning and follow-up on solar energy systems.

CENERGIA has participated in development of solar collectors and storage tanks and has planned a large number of small and large solar heating systems, including for municipal old peoples' homes. CENERGIA has experience of both water and airborne solar heating systems and systems with interseasonal heating storage.

Within the PV field (PV = photovoltaic that is direct transformation of sunlight to electricity), Cenergia works in a number of projects with integration of PV-modules in the weather screen of a building - roof and facades. CENERGIA is initiator of the EU-JOULE project PV-VENT, where an international cooperation team examines and demonstrates the possibilities of utilising PV-modules to run ventilation systems.

Passive solar heating is utilisation of solar energy for heating through deliberate design and orientation of buildings. As the building construction is included as a storage for the solar energy, the design has to be optimised by use of a dynamic simulation programme where the temperature in the building can be calculated hourly. To obtain the best possible utilisation of the passive solar heating it is important to take this into consideration very early in the planning process.

CENERGIA has participated in the preparation of BPS-directions and Northern and international planning manuals within the solar energy field.

Ecology - low-energy building – sustainability

CENERGIA's basic attitude is that sustainable human settlement is not just going to be for particular social categories, grass roots and fiery souls with the initiative and will to realise ecological building from the bottom, but should be a realistic possibility for everybody.

Based on and know-how from development and pilot projects, we develop and combine technologies that individually suit with future house owners' needs and requirements. At the same time, materials, constructions and installations are chosen to future technology, which as regards reliability comes up to traditional technology and whose operation is not unnecessarily complicated and time-consuming.

Fields of activity:

Energy savings, heating (reduction of transmission and ventilation loss);
Energy savings, electricity (lighting, refrigerator/freezer, washer, appliances);
Utilisation of solar energy (active and passive solar heating and PV-modules);
Heating systems for low-energy housing, low temperature heating;
Heat recovery;
Healthy building materials;
Product and material assessment by use of lifecycle assessments;
Involvement of tenants through recognition of the resource circulation;
Compost toilets;
Urine collection;
Wastewater treatment;
Water savings;
Rainwater drainage (fascines);
Rainwater collection
Natural ventilation

Natural ventilation

Natural ventilation can in many cases be used with advantage instead of mechanical ventilation in schools and day-care centres. CENERGIA has planned several systems and has very positive experiences from these. Today natural ventilation is more than just opening and closing windows. With a rather simple control system it is possible to open and close dampers in either supply or exhaust ducts, with which the CO2and temperature levels can control e.g. the ventilation. Moreover, dampers for air intakes are placed so the air can be preheated, by means of which annoying draught are avoided. Several parameters form part of the analysis of natural ventilation versus mechanical ventilation: To what extent can the necessary air change be reached with natural ventilation alone? Or is there a need to assist with a ventilating fan? What consequence does it have that it is usually not possible to recover heat from the exhaust air? What is the economy of mechanical and natural ventilation respectively? CENERGIA is in possession of computer tools and the necessary experience in application of these to answer the questions above. We have also made both quantitative (measuring of CO2 and temperature) and qualitative analyses of the air quality before and after the installation of natural ventilation systems.

Low-energy ventilation

Many ventilation systems have been made in these years without minding the energy consumption. CENERGIA has several years' experience of optimising ventilation systems from an energy-wise point of view by using e.g. low-energy ventilation fans and heat recovery with a high efficiency. An energy economical total assessment is usually made for each system.

Total economic optimisation

Preparation of a general concept of a new build or retrofit housing project based on a total economic optimisation of all possible energy saving technologies. The total economic optimisation is based on local parameters, heating, gas, electricity and water prices. The result - an economic prioritisation of all technologies - is used as base for composition of a concept that gives optimum energy savings without an increase of the rent for the tenants. CENERGIA has developed a special computer tool, Optibuild, for total economic optimisation.

Daylight

CENERGIA's work on ventilation and thermal conditions has had the result that the company has included another important room climate factor, daylight, with great advantage.

Together with acoustics, thermal comfort and air quality, light conditions affect peoples' wellbeing. CENERGIA has especially worked on daylight in connection with other techniques that have an influence on the daylight. E.g. the use of natural ventilation means that most of the used windows can be utilised as a ventilation source. By working with optimisation of daylight combined with optimisation of the natural ventilation it is possible to make a design that takes both matters into account.

Lifecycle assessment

CENERGIA works very deliberately on sustainable and ecological solutions. This means that it is necessary to work with lifecycle assessments. A lifecycle assessment means that the influence on the environment of a building is assessed from production to transport of building materials, energy consumption in a building and to demolition of the building.

The word assessment is used instead of analysis, as we are aware that a complete analysis requires a huge amount of information from producers and power stations. To be able to give useful advice, CENERGIA has participated in an EU-Thermie project about development of a practical and simple tool for lifecycle assessment. The result is called BEEAM (Building Energy and Environmental Assessment Method). BEEAM contains four methods with different detail levels and therefore it can be used in all phases of the planning.

CENERGIA does also work together with the Danish Research Institute on their development of a Danish lifecycle assessment program "BEAT". We attempt to affect the program to tend towards a practical tool for consultants.

Advanced calculation and simulation

CENERGIA’s role as a developer requires expert knowledge within advanced calculation and simulation methods. Therefore, CENERGIA keep informed within the research world through participation in Danish and international projects. CENERGIA’s employees have wide experience in and get continuing training in development and application of advanced simulation methods so we can go through innovative development projects when standard calculation methods are insufficient. CENERGIA have both calculation programmes that we have developed ourselves or participated in the development of (Optibuild, BEEAM) and commercial available programmes (TRNSYS, COMIS, SUNCODE, etc.).

3.2. Building insulation

The building insulation is very important for reducing the energy consumption of the heating system. It make the building easier to warm up and make it also easier to keep a constant temperature in the Building. The energy consumption of the heating system represents the biggest part of total energy consumption of the building. A good insulation combine with an efficient heating system reduce a lot the energy consumption.

3.2.1. Heat transmission mode

It is important to know how heat is transferred. It is transferred by conduction, convection or radiation, or by a combination of all three. Heat always moves from warmer to colder areas; it seeks a balance. If the exterior of a Building is colder than the indoor air, the Building draws heat from the inside. The greater the temperature difference, the faster the heat flows to the colder area.

Conduction

By this mode, heat energy is passed through a solid, liquid or gas from molecule to molecule in a material. In order for the heat to be conducted, there should be physical contact between particles and some temperature difference. Therefore, thermal conductivity is the measure of the speed of heat flow passed from particle to particle. The rate of heat flow through a specific material will be influenced by the difference of temperature and by its thermal conductivity.

Convection

By this mode, heat is transferred when a heated air/gas or liquid moves from one place to another, carrying its heat with it. The rate of heat flow will depend on the temperature of the moving gas or liquid and on its rate of flow.

Radiation

Heat energy is transmitted in the form of light, as infrared radiation or another form of electromagnetic waves. This energy emanates from a hot body and can travel freely only through completely transparent media. The atmosphere, glass and translucent materials pass a significant amount of radiant heat, which can be absorbed when it falls on a surface (e.g. the ship’s deck surface on a sunny day absorbs radiant heat and becomes hot). It is a well known fact that light-colored or shiny surfaces reflect more radiant heat than black or dark surfaces, therefore the former will be heated more slowly.

In practice, the entry of heat into a Building is the result of a mixture of the three modes mentioned above, but the most significant mode is by conduction through walls and flooring.

3.2.2. Definition

The thermal properties of insulating materials and other common Building construction materials are known or can be accurately measured. The amount of heat transmission (flow) through any combination of materials can be calculated. However, it is necessary to know and understand certain technical terms to be able to calculate heat losses and understand the factors that are involved.

By convention, the ending -ity means the property of a material, regardless of its thickness and the ending -ance refers to the property of a specific body of given thickness.

Heat energy

One kilocalorie (1 kcal or 1 000 calories) is the amount of heat (energy) needed to raise the temperature of one kg of water by one degree Celsius (°C). The SI standard unit for energy is Joule (J). One kcal is approximately 4.18 kJ (this varies slightly with temperature). Another unit is the Btu (British thermal unit). One Btu corresponds roughly to 1 kJ.

Thermal conductivity

In simple terms this is a measure of the capacity of a material to conduct heat through its mass. Different insulating materials and other types of material have specific thermal conductivity values that can be used to measure their insulating effectiveness. It can be defined as the amount of heat/energy (expressed in kcal, Btu or J) that can be conducted in unit time through unit area of unit thickness of material, when there is a unit temperature difference. Thermal conductivity can be expressed in J m^{-1} $°C^{-1}$ and in the SI system in watt (W) m^{-1} $°C^{-1}$. Thermal conductivity is also known as the k-value.

Coefficient of thermal conductance " l" (J m^{-2} h^{-1} $°C^{-1}$)

This is designated as l (the Greek letter lambda) and defined as the amount of heat (in J) conducted in one hour through 1 m^2 of material, with a thickness of 1 m, when the temperature drop through the material under conditions of steady heat flow is 1 °C. The thermal conductance is established by tests and is the basic rating for any material. l can also be expressed in SI units in W m^{-2} Kelvin $(K)^{-1}$.

Thermal resistivity

The thermal resistivity is the reciprocal of the k-value (1/k).

Thermal resistance (R-value)

The thermal resistance (R-value) is the reciprocal of l (1/l) and is used for calculating the thermal resistance of any material or composite material. The R-value can be defined in simple terms as the resistance that any specific material offers to the heat flow. A good insulation material will have a high R-value. For thicknesses other than 1 m, the R-value increases in direct proportion to the increase in thickness of the insulation material. This is *x*/l, where *x* stands for the thickness of the material in meters.

Coefficient of heat transmission (U) (J m-2 h-1 °C-1)

The symbol U designates the overall coefficient of heat transmission for any section of a material or a composite of materials. The SI units for U are J per square meter of section per hour per degree Celsius, the difference between inside air temperature and outside air temperature. It can also be expressed in other unit systems. The U coefficient includes the thermal resistances of both surfaces of walls or flooring, as well as the thermal resistance of individual layers and air spaces that may be contained within the wall or flooring itself.

Permeability to water vapor (pv)

This is defined as the quantity of water vapor that passes through the unit of area of a material of unit thickness, when the difference of water pressure between both faces of the material is the unit. It can be expressed in the SI system as g m MN^{-1} s^{-1} (grams meter per mega Newton per second).

Resistance to water vapor (rv)

This is the reciprocal of the permeability to water vapor and is defined as rv = 1/pv.

3.2.3. Contribution to energy loss

Building insulation is made for avoid Heat exchange from inside to outside, if the inside air is warmer than outside air, if it is the opposite the heat come from the outside to the inside. Insulation types depend of the climate and the location of the building. There is different part of the house where warm air can go outside and cooling down the building. Those parts are:

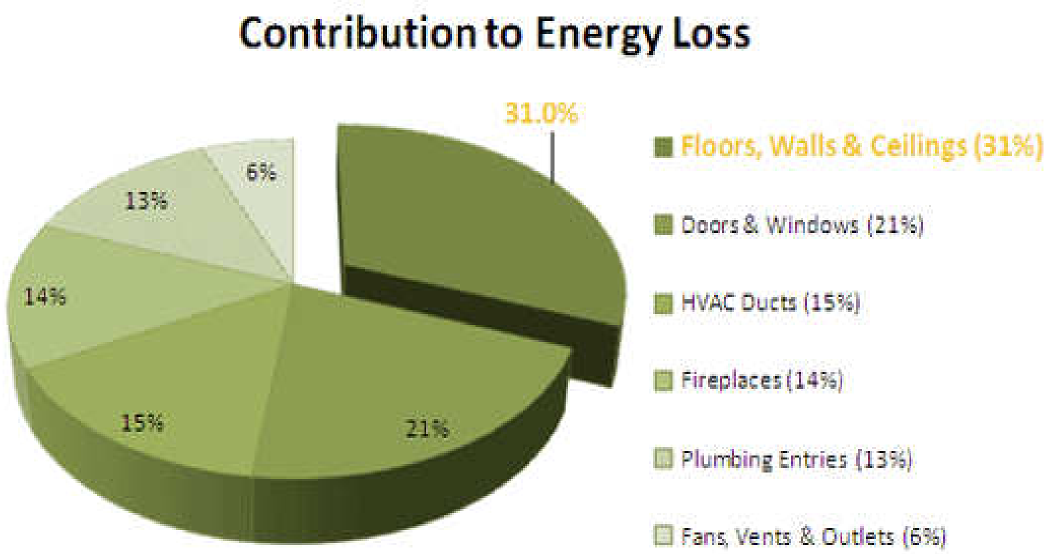


Figure 3.2.1. *Energy loss diagram.*
http://www.evergreen-builder.com

But a heavy insulation can create some problems in term of cost and the reduction of free space. Few centimetres of glass wool have better insulating properties than basic walls. Without insulation wall is cold and generate condensation and some water on the wall which encourage the development of mold. Insulation act as an envelope for the building, it stop heat exchange and avoid any other problem linked to this.

3 types of insulation exist:

-Indoor insulation, which is the more easy to make. It consist of an insulating layer put on the inside of construction. With this process, the heavy construction do not get heat energy from building. And don't need to warm up the wall for have constant temperature, so the building became faster to warm up. But with such insulation, contraction lifetime is shorter because it is exposed to outside conditions.

-Outdoor insulation. Comparing with inside isolation it is a little bit more expensive because of front cover material (decorative layer/plaster/panel). It takes more time to warm up building, because constructions absorb heat energy. It make heat inertia and it provides a uniform temperature.

-Integrated insulation, the walls are made of a mix of concrete (or other building material) and insulator directly integrated to the wall. Disadvantage of this insulation is that it makes many thermal bridges.

The best insulation is air. It is the air (or other gases) enclose between the fibers (polystyrene, wood, Glass wool etc...) which stop the thermal transfers.

The best type of insulation is the outdoor insulation. Comparing with indoor isolation this way of insulation doesn’t generate thermal bridges. There is less condensation possibility with this type of insulation. It is a little bit more expansive. In Denmark, the main material used for insulation is glass fiber (and wool) and wood.

3.2.4. Different insulating materials

Glass wool insulation.

Glass wool is made from silica glass recovery, fusion and polymerization and fiber drawing. Its density is between 15 and 25kg/m3, so it is a lightweight material.

Very efficient and inexpensive, the glass wool insulation material is sold in the entire world. Based on combustible minerals, glass wool is not flammable.

According to WHO, glass wool does not present a health risk. The skin irritation that can occur during installation are mechanical and not chemical, so harmless, and they disappear after rinsing with water. Once installed, the glass wool causes no irritation.

Figure 3.2.2. *Picture of wool fiber panels.*
http://www.antiquesurveying.com

Styrofoam insulation

Formed from crude oil, expanded polystyrene (EPS) contains a multitude of beads connected by compression during molding and which trap the dry air still. This provides a lightness to the material (between 10 and 30 kg/m3) and a high mechanical strength.

Highly flammable, the polystyrene foam requires a combination of a combustible material such as plaster. When should remain apparent, this insulation must be fireproof.

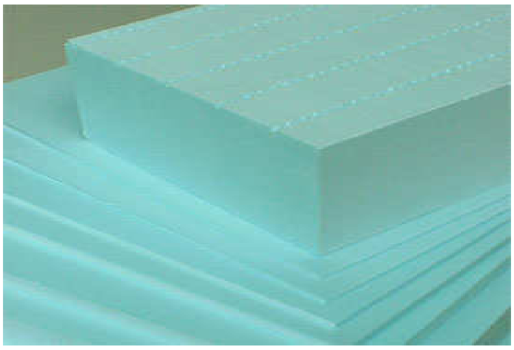


Figure 3.2.3. *Styrofoam into panel form*
http://www.styrocut.de

Figure 3.2.4 *Styrofoam into chip form*
http://www.huali-dl.com

Polyurethane insulation

Polyurethane (PUR) is a material commonly used to fill defects in insulation. It is a lightweight (density 40 kg/m3) effective and adaptable.

It is dangerous in case of fire as it emerges carbon monoxide. Associated with flame retardants, can also release toxic gases to the nervous system of man.

Figure 3.2.5. *Polyurethane panels.*
http://img.archiexpo.com

Thin insulating

The thin insulation, also called thermo-reflective insulation is a new generation of insulation.

Insulation is lightweight and thin, which varies from a few millimeters to several centimeters:

* It consists of one or several layers of aluminum fitted together and intermediate layers of different natures: felt, wool, foam, etc..
* These layers act as reflectors, that is to say, they return the thermal radiation and prevent the heat loss.
* The thin insulation is commonly used for insulating attics. It can also be used to insulate the roof, floor or walls.

Properties of this material

The thin insulation has many qualities:

* It is a lightweight insulation, thin, comfortable and easy to install because of its flexibility and maneuverability.

* Since its thinness, it greatly increases the dwelling thinner walls, ceiling height greater compared to a thicker insulation.
* The thin insulation is also a healthy product that poses no health risk and does not contain carcinogenic compound.

Thermal and phonic performance of thin insulation

The thin insulation must be used to supplement and not isolating one.

Indeed the thermal resistance is quite low and its ability to soundproofing are good.

Used to supplement other insulating thin insulation is very effective in summer and winter:

* Winter:
    * thin insulation keeps heat in and prevents the return of cold;
    * it reduces the temperature loss through the walls;
* In summer it serves as a barrier against heat and sunlight.

Longevity of this material

The thin insulation has a high durability and resistance to time. It is a durable material that resists moisture and rodents.

The thin insulation is lightweight, flexible and manageable, making it easy and fun to install. it can be placed on all forms and all surfaces and requires only one cutter, cutting and stapling.

Prices of thin insulating

The price of thin insulation varies from 5 to 10 € per m², or 100 to 200 € the 20 m²

Figure 3.2.6. *Thin insulator picture.*
http://img.archiexpo.com

Wood fiber Insulation.

Renewable and made of natural wood - if properly managed - is a practical resource and ecological isolation.

Thermal and phonic performance of wood fiber

The wood fiber provides excellent performance for thermal insulation. Its coefficient of thermal conductivity λ is between 0.039 and 0.049 W / m.K

It is also effective as a sound insulator, against airborne and impact. The wood fiber has the property of absorbing the sounds, whatever their frequency range.

Terms of laying the wood fiber

Insulation fibers of wood are offered mainly in the form of rigid panels of different densities, but they are also semi-rigid panels and grooved boards with a water proof treatment .

As for the insulation of plant type, they must be protected from the habitable part by non-flammable materials such as plaster.

Wood fiber is used:

* For roof insulation from the outside.

* For insulation under slabs and floors.

* For insulation in external walls cladding.

* For the insulation of wood frame buildings.

* For insulation inside walls and partitions.

The wood fibers are used in bulk for filling voids sloping roof, walls and floors.

Longevity

This excellent insulation aging well.

* Not flammable, it does not emit toxic fumes. Treatment with fireproofing provides good performance in front of the fire.

*With its Hygroscopic properties, it can store moisture. It purify the air in the house and regulate humidity.

Price of wood fiber

15 to 20 € / m² to 100 mm thick and 6-7 € for 40 mm.

Figure 3.2.7. *Picture of wood fiber panel.*
http://farm3.static.flickr.com

PIV: panels of insulating vacuum

The PIV represents the new generation of insulation with exceptional thermal qualities. Utra-thin, it is composed of a material "soul" contained in a waterproof film and put in depression.

Extremely powerful, it is still not widespread on the market because its prices even higher.

Thermal and phonic performance.

The PIV, isolating new generation, offering exceptional thermal capacity. Its coefficient of thermal conductivity λ is in effect between 0.0042 and 0.0050 W / m.K.

On the sound, its qualities are still little studied, but the material "soul" of insulation consisting of aerogels, it has a good ability to reduce noise.

Installation conditions of panels vacuum insulation

* The signs of insulation vacuum should be laid in two layers with cross joints staggered to avoid thermal bridges caused by the butt. The main drawback of this material is its fragility: it must not be drilled.

* Panels can not be cross-referenced, so be sure to know the precise measurements of surfaces.

* The PIV fits perfectly flat surfaces.

* Very efficient, the PIV demand a small thickness. It may well be sufficient in 30 mm, which makes it particularly to gain interior space or during renovations.

Longevity of these panels

* The PIV is not permeable to water vapour but the installation of a vapour barrier is recommended.

* They have good resistance to compression.

* The placement of a single gypsum board in the VIP protection will be kept out of holes and borings.

Still rare on the market, produced in smaller quantities compared to mineral wool, the PIV is an insulator expensive: between 40 and 60 € per m². But his performance is really excellent, it's a safe bet that prices will decline in coming years.

Figure 3.2.8. *Two pictures of PIV panel.*
http://www.nrc-cnrc.gc.ca

3.2.5. Windows Insulation

Energy losses through the windows are also an important issue for building Insulation. The most common Insulating window is the double glazed windows. But many types of those windows are available depending on the properties required. But basically the double glazed windows are composed of two glass layer (and adding some other special material layers which modify the Properties of the glass) separate by a thin space with trapped air (which is a very good thermal and phonic insulation).

Tinted glass

Tinted glass may be used to reduce solar heat gain or as an architectural feature. The principal colours available are bronze, gray and green. The degree of tint depends on both the composition of the glass and the thickness of the coating. Tinted glass is usually placed on the exterior Layer of the window. It almost always requires heat-treatment to reduce potential thermal stress and breakage and tends to re-radiate the absorbed heat.

Low-emissivity glass (Low -e)

Low emissivity glass has a thin coating, often of metal, on the glass within its airspace that reflects thermal radiations or inhibits its emission reducing heat transfer through the glass. A basic low-e coating allows solar radiations to pass through into a room. Thus, the coating helps to reduce heat loss but allows the room to be warmed by direct sunshine. The change in location of the coating does not affect the insulating properties of the window, only the percentage of solar heat gain.

There are two types of low-e coatings available, "hard-coat" or pyrolytic and "soft-coat" or sputtered. Hard-coat glass is manufactured using the Atmospheric Pressure Chemical Vapor Deposition (APCVD) method of applying a doped tin composition to the glass surface as the glass sheets are being manufactured in the hot tin bath of a glass float plant, or alternatively in an offline furnace process. The tin bonds to the surface of the glass and forms a relatively thick coating. Hard-coat glass is considered a low to medium performance coating since the emissivity is greater (about 10 times) compared to the sputtered coating. The advantage of hard-coat glass is that it does not require special handling in the window assembly process to maintain the surface's coating integrity and does not scratch easily. It does require that the glass surface in contact with the spacer be abraded to improve adhesion of the sealant.

The properties of double glazed windows can be very different depending of composition of the different layers add to the glass. But it is now a very common process and most of buildings are using this technology for thermal and phonic Insulation.

3.3. Ventilation system

A basic requirement for living in a healthy house is to have good ventilation, which provides an inside air completely hygienic. This is why we must take care about the ventilation in our low energy house.

In order to avoid the Sick Building Syndrome (SBS), we must avoid toxic pollution from chemical substances and dust inside the building, accumulation of microbes, bacteria and viruses, and reduce the exposure to allergens. We can obtain it with a good ventilation system, which must be low energy, of course.

Reducing the SBS is also a way to reduce costs about healthy, as we can see at the web page: http://www.nibe.co.uk/NIBE-Heat-Pumps/Exhaust-air-heat-pumps/ , it says that:

'From a health and allergy perspective, the ideal air exchange rate would be 0.5 – 1.0, but in actual fact, air ex change rates in appropriately insulated houses are only between 0.3 and 0.5, which means that the polluted inside air is exchanged far too in-frequently. Based on the reasons given above, an increase in the incidence of complaints affecting the population is inevitable. This is where controlled domestic ventilation can have a particular role to play. Its purpose is to control temperature and dampness, while ensuring that the quality of the inside air is totally hygienic. The relevant technical guidelines and hygiene regulations are stipulated by DIN 1946.'

And about the controlled domestic ventilation, it says: 'Nowadays we spend around 90% of the time indoors. This undoubtedly places great demands on the climate inside. The inside climate is affected considerably by odours, harmful substances, noise and temperature. In every building there is a certain amount of basic ventilation, even if it is only produced by air coming through windows, doors, pipe ducts and walls. This type of ventilation, in older houses in particular, provides the necessary exchange of air. Ventilation is also provided through opening windows and doors, perhaps also when one or more windows are opened at an angle. Strong wind pressure and a difference in temperature between the interior and the exterior also increase the exchange of air. On the other hand, a weak wind or small temperature difference will reduce the required air exchange rate. This uncontrolled ventilation also accounts for a significant part of the heating costs and causes a considerable proportion of non-renewable energy resources to be wasted. Low-energy house In contrast to this, there is the low-energy house concept. A construction design is used in this type of house that prevents heat from escaping through use of effective thermal insulation. This also means that low-energy houses benefit the environment. But even with this construction design, there is still the problem that the required hourly air exchange rate of 0.5 – 1.0 is not achieved. To achieve the required air exchange rate either the windows would have to be opened, which would run counter to the whole low-energy house concept, or installation of a controlled domestic ventilation system with heat recovery would have to be considered.

Controlled domestic ventilation can be used in both low-energy and older houses. In low-energy houses the controlled ventilation system guarantees the required air exchange rate, even with the doors and windows closed. When older houses are renovated better thermal insulation could be used, along with fitting new windows to enable controlled domestic ventilation to achieve the necessary air exchange rate. These types of older building are often affected by street noise. A ventilation system would therefore be beneficial in these cases too. Controlled domestic ventilation with heat recovery When ventilation based on opening windows and controlled domestic ventilation without heat recovery are used, the energy from the inside air is not used. However the ventilation heat requirement accounts for a considerable part (40 – 50%) of the total heat requirement. In contrast to this, controlled domestic ventilation with heat recovery reuses the energy from the exhaust air. Not only that, the additional heat generated internally from lighting, people and domestic appliances is also utilised through heat recovery. Our fighter exhaust air heat pumps facilitate heat recovery and supply the energy recovered from exhaust air for the domestic hot water and even the heating. Not only does energy recovery ensure a healthy and comfortable form of heating, it also produces considerable savings in terms of heat energy, along with CO2 emissions.'

From: http://www.nibe.co.uk/NIBE-Heat-Pumps/Exhaust-air-heat-pumps/

In the next table it can be seen the common sources and types of pollutants, that they can be avoid with ventilation systems:

Common sources and types of pollutants Table:

Outdoor sources Pollutant Types	**Outdoor sources Pollutant Types**
Ambient air	SO_2, NO, NO_2, O_3 Hydrocarbons, CO, particulates and lead compounds
Motor vehicles	Exhaust pollutants including CO

Indoor Sources	**Pollutant Types**
Building Construction Materials Soil Particle board Insulation FIRE retardant Adhesives Paint	 Radon Formaldehyde Formaldehyde, fiberglass Asbestos, valtile organic compounds (VOC) Organics Mercury, organics
Building Contents Heating and cooking Furnishings Water service	 CO, SO_2, NO, NO_2, particulares Organics, odors Radon
Human Occupants Metabolic activity	 CO_2, NH_3, organics, odors, virases
Human Activities Tobacco smoke Aerosol devices Cleaning and cooking products Hobbies and crafts	 CO, NO_2, HCN, organics, odors Fluorocarbons, vinyl chloride Hydrocarbons, odors, NH_3 Organics

Figure 3.3.1.- *Common sources and types of pollutants table.*

In our project we must perform ventilation systems efficient for the whole building, so it will part of the study calculate how big must be this system. We must also think about the economic part, both for the saving and for the ecological reasons, so the best way to perform is by a heat recovery ventilation system, that can recovery the heat from inside, and transmit it to the cool air from outside, as you can see in the next text.

3.3.1. Heat Recovery Ventilation System

According to a text extracted from: http://www.soloheatinginstallations.co.uk/heat_recovery.htm , the air that you breathe inside your home could be up to ten times more polluted than the air by a busy road. In our project we want to use a Recovery Ventilation Systems, that reduce energy consumption at home, by recovering the wasted heat, by a heat exchanger.

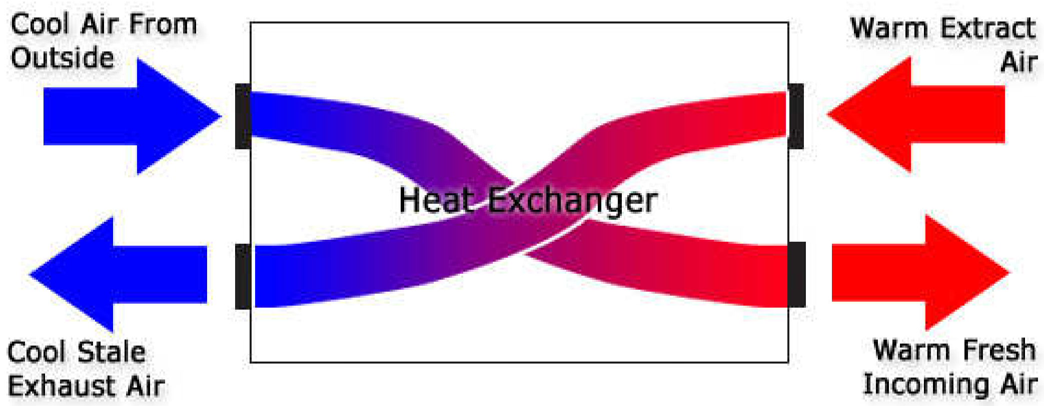


Figure 3.3.2-. *Heat Exchanger.*
http://www.soloheatinginstallations.co.uk/heat_recovery.htm

As it says at http://www.soloheatinginstallations.co.uk/heat_recovery.htm : 'A heat recovery system will keep your house fully ventilated all year long, by recovering the heat already inside your home. It brings fresh air from the outside and recycles the wasted heat from bathroom and kitchen areas. Anywhere where there is a high heat or humidity will be used to power the heat recovery unit and keep efficiencies high.

Very old properties, although sometimes quite difficult to install, will benefit greatly from a mechanical heat recovery ventilation system. Moisture and stale air can cause lasting damage to Grade 2 listed and older homes. This is where a heat recovery system can count towards protecting the actual fabric structure of the building, along with the comfort of the inhabitants occupying it.'

The cost of this Heat Recovery Ventilation System in a new property, is about 400 DKK, including the electrical components.

The Heat Recovery Systems works this way:

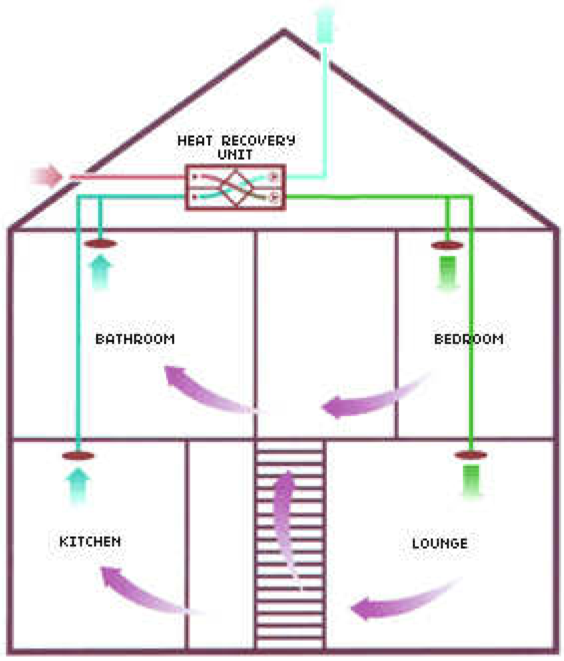


Figure 3.3.3.- diagram of working of a heat recovery unit.
http://www.soloheatinginstallations.co.uk/heat_recovery.htm

Step 1 - Extract stale air from wet parts.

Dirty, stale air is continually extracted from all the wet areas of the home, through unobtrusive white ceiling or wall mounted grilles.

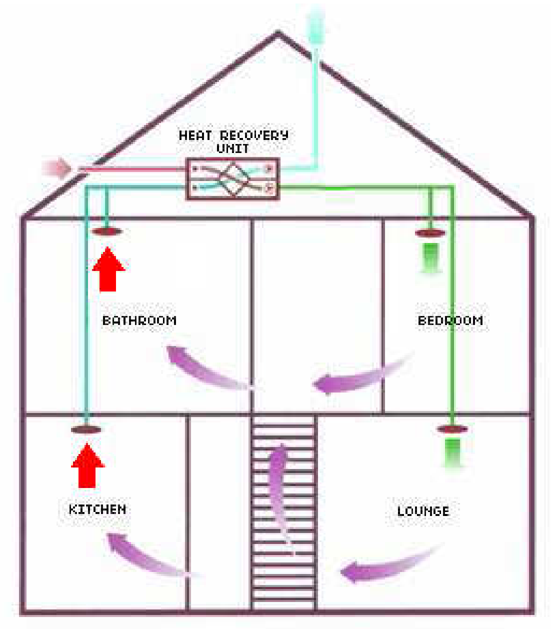


Figure 3.3.4.- *Step 1. Diagram of working of a heat recovery unit.*
http://www.soloheatinginstallations.co.uk/heat_recovery.htm

Step 2 - Take fresh air from the outside.

This air then makes its way through the ducting and the long rigid silencer, back to the heat recovery unit. Before being discharged outside, it passes through the plate or rotary wheel heat exchanger giving up its heat to the cold fresh air coming into the house.

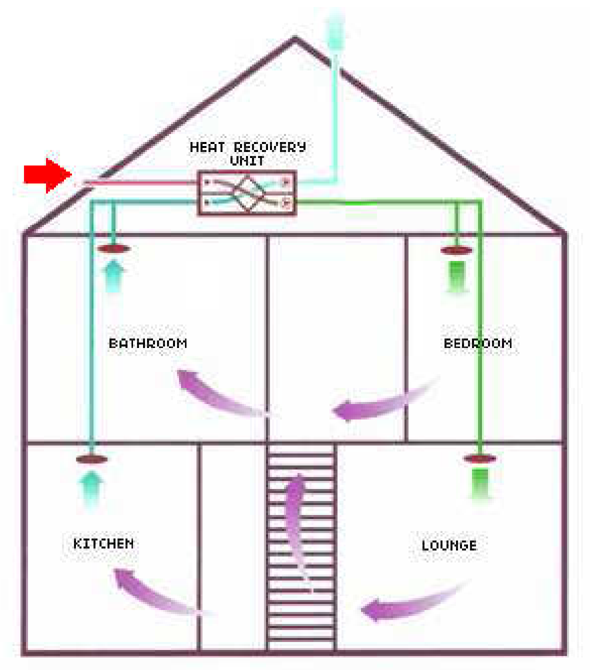


***Figure** 3.3.5.- Step 2. Diagram of working of a heat recovery unit.*
http://www.soloheatinginstallations.co.uk/heat_recovery.htm

Step 3 - Warm the fresh air with the heat from the stale air.

The highly filtered supply air is heated up to the required temperature by the water heater coil (linked to your wet heating system) or an electric heater coil ensuring no cold draughts, which must be avoided. The heat recovery unit controls the extra heat requirements automatically.

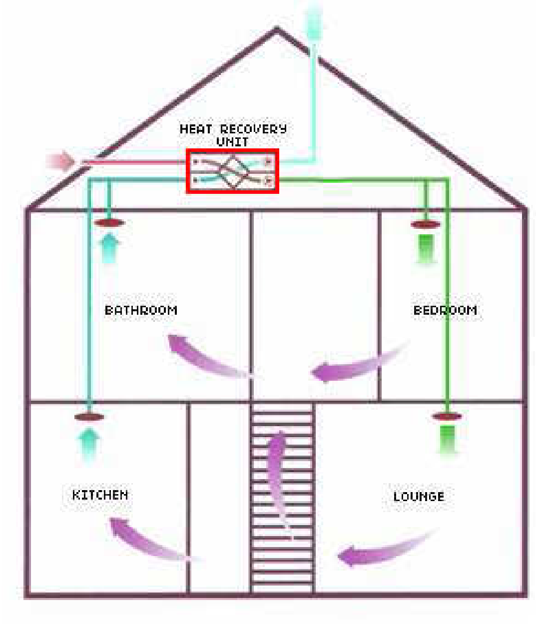


Figure 3.3.6.- *Step 3. Diagram of working of a heat recovery unit.*
http://www.soloheatinginstallations.co.uk/heat recovery.htm

Step 4 - The air is delivered.

The supply air is now delivered through a long rigid silencer into the supply ducting, through ceiling or wall mounted supply registers, to all the habitable rooms resulting in whole house heat recovery ventilation.

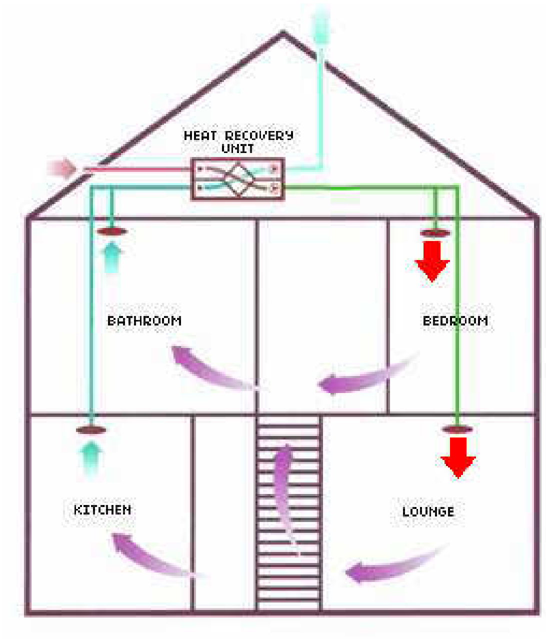


Figure 3.3.7.- *Step 4. Diagram of working of a heat recovery unit.*
http://www.soloheatinginstallations.co.uk/heat recovery.htm

It is common practice to have two or more heat recovery units working in one large home; and they can be positioned to serve zones or floors of their own.

So in our project we must evaluate how many heat recovery units we need, for the whole building, and how much energy and money we can save.

3.3.2. Ventilation in Denmark – Status and Future Trends

Through the project by Per Heiselberg, from the Department of Civil Engineering at Aalborg University we can identify the status and future trends of the ventilation in Denmark.

3.3.3. Standards & Regulations

• New Building regulations in 2008 (replaces 1995 regulations)

• New Code of Practice for Mechanical Ventilations Systems in 2005, DS447 (replaced previus from 1981).

• Only minor changes regarding minimum air flow rates and critia for IAQ.

• The main changes with regard to ventilation are consequences of new demands for energy use.

• Different indoor environmental quality levels are introduced.

Residences: Minimum Air Flow Rates

• In every room as well as for the whole residence the supply of outdoor air shall be minimum 0,35 l/s m^2 ~ (0,5 h-1 at normal room height).

• The air flow shall be provided on a 24 hours basis (demand control not allowed).

• Air shall be supplied either though vents, controlled windows or mechanical suply.

• Air shall be exhausted from kitchen (20l/s), bathroom (15 l/s), toilet (15 l/s) and similar rooms.

• All residences shall have a cooker hood in the kitchen with mechanical exhaust.

Criteria for Energy Use for Ventilation

• Minimum heat recovery 65 %

• Specific Fan Power (SFP)

– Constant air volume (CAV) 2.1 kW/(m^3/s)

– Variabel air volume (VAV) 2.5 kW/(m^3/s)

– Mechanical exhaust 1,0 kW/(m^3/s)

– Residences (CAV) 1,2 kW/(m^3/s)

• Humidification can only be used if aspects related to production, security, conservation or health demand it.

Building Airtightness

• Building airtightness should be less than 1,5 l/s m^2 floor area at 50 Pa.

• Documentation can be required in the building permit (minimum 5% of the cases).

Political Agreement of February 21, 2008

• 20% renewable energy in 2011 (minimum 30% in 2020).

• Energisavings on average 1,5% in 2010-2020 (total about 16%).

• Demands for energy use in new buildings are reduced by at least 25% in 2010, 2015 and 2020 to a maximum of 25% of todays demand in 2020.

Future Trends: Ventilation in Residences

• Energy requirements drive a change towards balanced mechanical ventilation with heat recovery.

• Heat recovery efficiency will have to increase from 65% to minimum 75%-80% in 2015 (keeping SFP at the same level or lower).

• Increased need for cooling in low energy residences – natural ventilation and night cooling hended.

• Demand control in residences might be possible in the future, but this requires suitable criteria for health and comfort.

3.4. Hot water heating using sun collectors and heating system

3.4.1. Solar Radiation Energy in Denmark

In Denmark the sun shines average 1,800 hours per year. Solar energy is one of renewable energy resource, its use is friendly for environment. In Denmark the solar radiation is about 1000 kWh/m^2 per year on a horizontal plane and about 1150 kWh / m2 per year on surfaces with an inclination 40 degree angle to the horizon and the location to the south.

The following table compares solar radiation data in Denmark, southern Spain and the Sahara, which is the one of the sunniest areas in Europe and the world. As the table shows it is possible to get 2.6 times less solar energy per year in Denmark than the Sahara. This factor is even slightly below the 2.6, when the angle is optimal (40°). The major difference between Denmark and the Sahara is that the solar radiation is much more variable in Denmark than in the Sahara. During the summer months solar activity in Denmark is much higher than in the winter months.

Solar radiation per year *(3.4.1.table)*

	On the horizontal surface		On the surface the optimum angle		
	kWh/per year/m^2	coefficient	Incidence angle	kWh/per year/m^2	coefficient
Denmark	1000	1.00	40°	1150	1.00
southern Spain	1800	1.80	30°	2000	1.75
Sahara	2600	2.60	20°	2700	2.35

http://www.solenergi.dk/SEC/visTekst.asp?id=62

Solar radiation is not equal in all Denmark. In the picture below you can see the solar radiation distribution in Denmark. The scale is kWh/m ^{2}/per year in picture

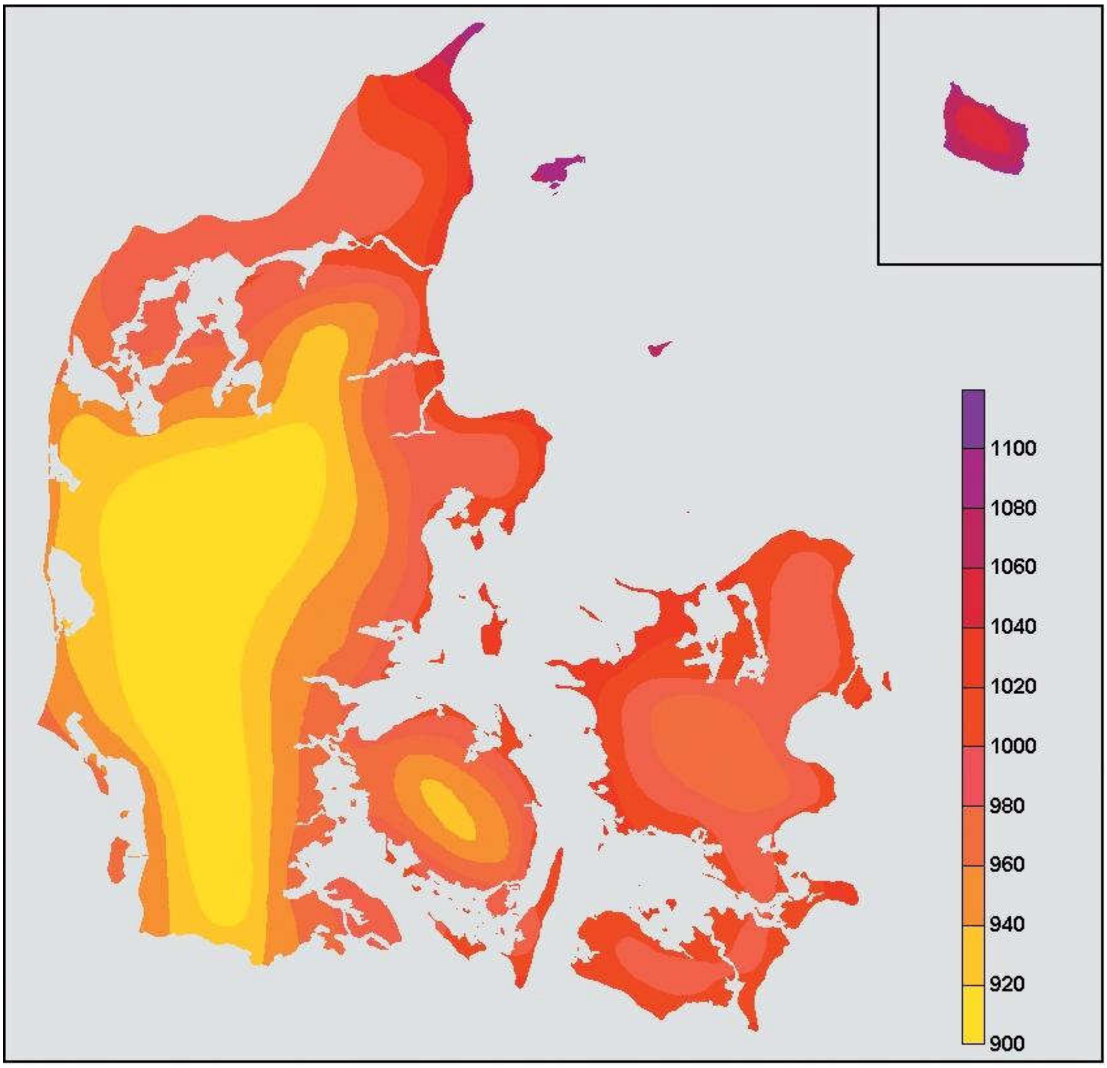


Figure 3.4.1. *Solar radiation distribution in Denmark*
http://www.solenergi.dk/SEC/Grafik/Solindstr%C3%A5lingskort.jpg

3.4.2. Heat water for house using energy from the sun

Solar water heating systems use free heat from the sun to warm domestic hot water. A conventional boiler or immersion heater is then used to make the water hotter, or to provide hot water when solar energy is unavailable.

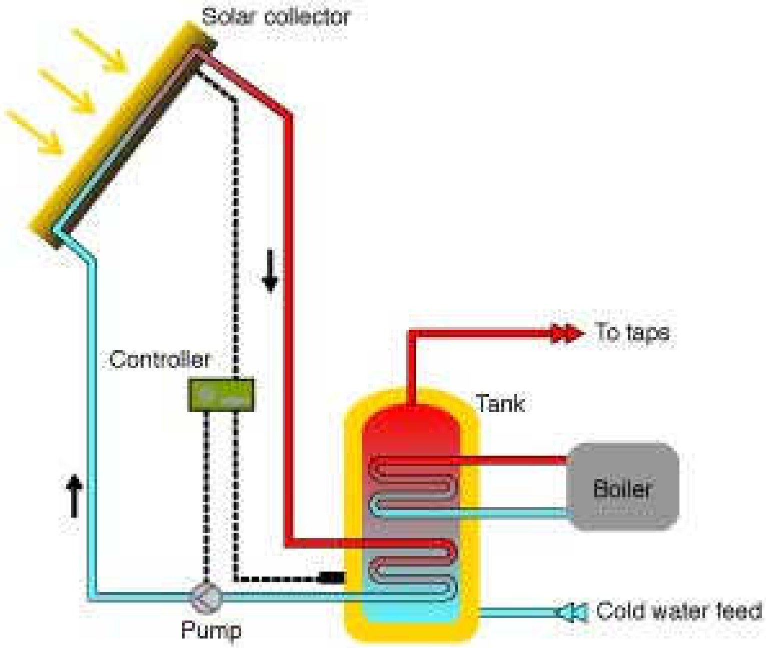


Figure 3.4.2 *Hot water heating system with solar collectors*
http://www.solarage.co.uk/spaw/plugins/imgpopup/img_popup.php?img_url=/spaw/../res/embedded/swhsystem.gif

Solar water heating systems

Solar water heating systems use solar panels, called collectors, fitted to roof. These collect heat from the sun and use it to warm water which is stored in a hot water cylinder.

3.4.3. Solar Collectors

At the heart of a solar thermal system is the solar collector. It absorbs solar radiation, converts it into heat, and transfers useful heat to the solar system. There are a number of different design concepts for collectors: besides simple absorbers used for swimming pool heating, more sophisticated systems have also been developed for higher temperatures, such as integral storage collector systems, flat-plate collectors, evacuated flat-plate collectors and evacuated-tube collectors.

There are two main types of solar water heating panels - they are :

- flat plate collectors
- evacuated tubes

Residential and commercial building applications that require temperatures below 80°C typically use flat-plate collectors, whereas those requiring temperatures higher than 80°C use evacuated-tube collectors.

Flat-plate collectors

The majority of solar collectors that are sold in many countries are of the flat-plate variety. The main components of these are a transparent front cover, collector housing and an absorber. The absorber, inside the flat plate collector housing, converts sunlight to heat and transfers it to water in the absorber tubes. As the collector can reach stagnation temperatures up to 200°C (i.e. when no water flows through), all the materials used must be able to resist such heat. Therefore, the absorber is usually made of metal materials such as copper, steel or aluminium. The collector housing can be made of plastic, metal or wood, and the glass front cover must be sealed so that heat does not escape, and dirt, insects or humidity do not get into the collector itself. Many collectors also have controlled ventilation, so as to avoid condensation inside the glass front cover. The collector housing is highly insulated at the back and sides, keeping heat losses low. However, there are still some collector heat losses, mainly due to the temperature difference between the absorber and ambient air, and these are subdivided into convection and radiation losses. The former are caused by air movements, while the latter are caused by exchange of heat by radiation between the absorber and the environment.

A sheet of glass covers the collector as it faces the sun, and this helps to prevent most of the convection losses. Furthermore, it reduces heat radiation from the absorber into the environment in a similar way as a greenhouse does. However, the glass also reflects a small part of the sunlight, which does not then reach the absorber at all. Figure 3.4.3 shows the processes occurring at a flat-plate collector.

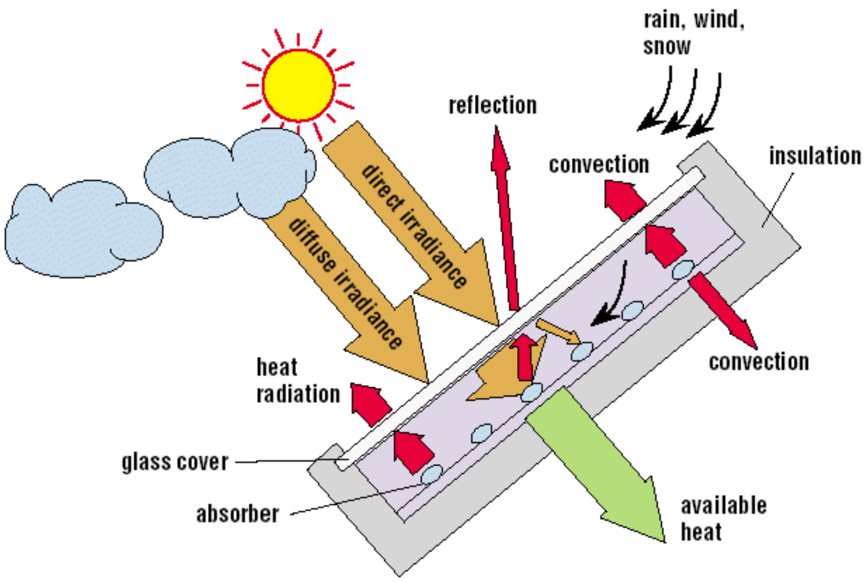


Figure 3.4.3 *Figure with processes occurring at a flat-plate collector*
http://www.volker-quaschning.de/articles/fundamentals4/index.php

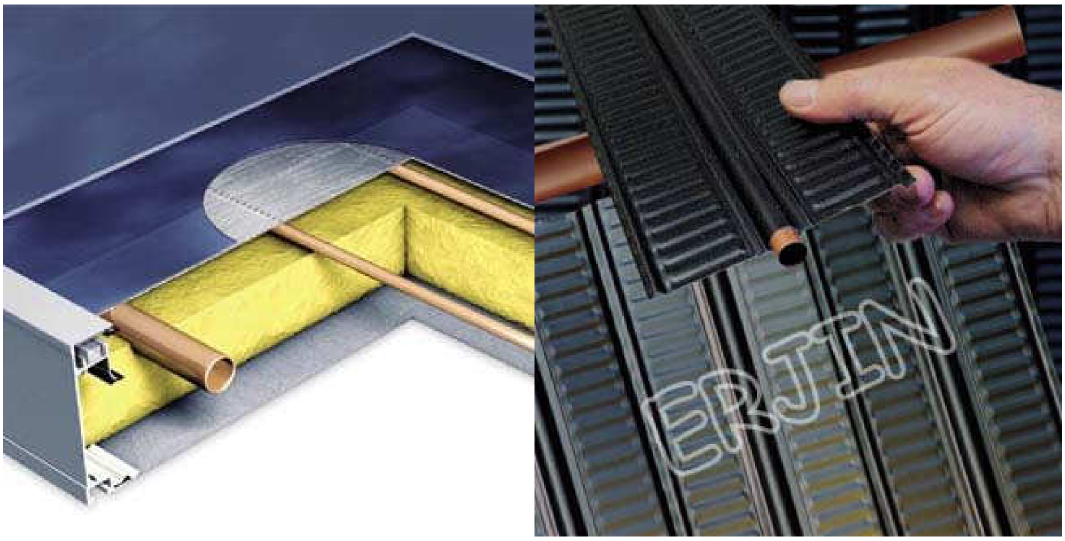


Figure 3.4.4. *Flat-plate collectors*
http://www.siliconsolar.com/shop/solarimages/sunmaxxm2-solar-flat-plate-collector-p-501608_T_2.jpg

Flat-plate collectors are used for residential water heating and hydronic space-heating installations.

Flat-plate collectors heat liquid as it flows through tubes in or adjacent to the absorber plate. The simplest liquid systems use potable household water, which is heated as it passes directly through the collector and then flows to the house.

Evacuated-tube collectors

Picture 3.4.5. *Evacuated-tube collectors*
http://www.treehugger.com/files/2008/03/solar-hot-water.php

Evacuated-tube collectors can achieve extremely high temperatures (80°C to 180°C), making them more appropriate for commercial and industrial application. Evacuated-tube collectors are efficient at high temperatures.

The collectors are usually made of parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin is covered with a coating that absorbs solar energy well, but which inhibits radiative heat loss. Air is removed, or evacuated, from the space between the two glass tubes to form a vacuum, which eliminates conductive and convective heat loss.

There are two main tapes of Evacuated – Tube Collectors:

- **Direct-flow evacuated-tube collectors**
- **Heat pipe evacuated-tube collectors (integral collector-storage (ICS)**

3.4.4. Direct-flow evacuated-tube collectors

A direct-flow evacuated tube collector has two pipes that run down and back, inside the tube. One pipe is for inlet fluid and the other for outlet fluid. Since the fluid flows into and out of each tube, the tubes are not easily replaced. Also, should a tube break, it's possible that all of the fluid could be pumped out of the system - if a closed loop is used, or your water will flow out as in a broken pipe, if an open loop is used.

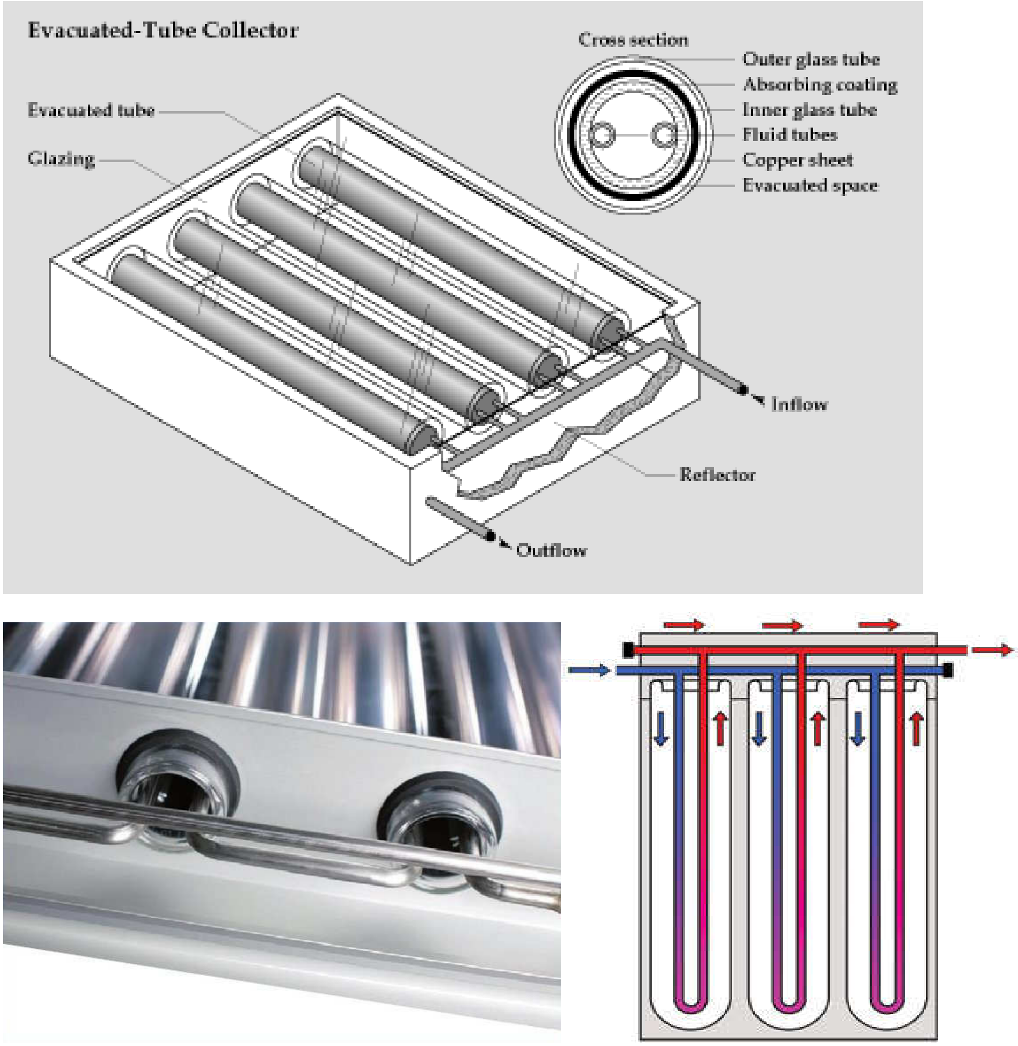


Figure 3.4.6. *Direct-flow evacuated-tube collectors*
http://www1.eere.energy.gov/buildings/commercial/water_heating.html
http://www.gs-solarhotwater.co.uk/evacuated-tube-solar-hot-water-collectors.html

3.4.5. Heat pipe evacuated-tube collectors (integral collector-storage (ICS))

Heat pipe evacuated tube collectors contain a copper heat pipe, which is attached to an absorber plate, inside a vacuum sealed solar tube. The heat pipe is hollow and the space inside is also evacuated. Inside the heat pipe is a small quantity of liquid, such as alcohol or purified water plus special additives. The vacuum enables the liquid to boil at lower temperatures than it would at normal atmospheric pressure. When sunlight falls the surface of the absorber, the liquid in the heat tube quickly turns to hot vapor and rises to the top of the pipe. Water or glycol, flows through a manifold and picks up the heat. The fluid in the heat pipe condenses and flows back down the tube. This process continues, as long as the sun shines.

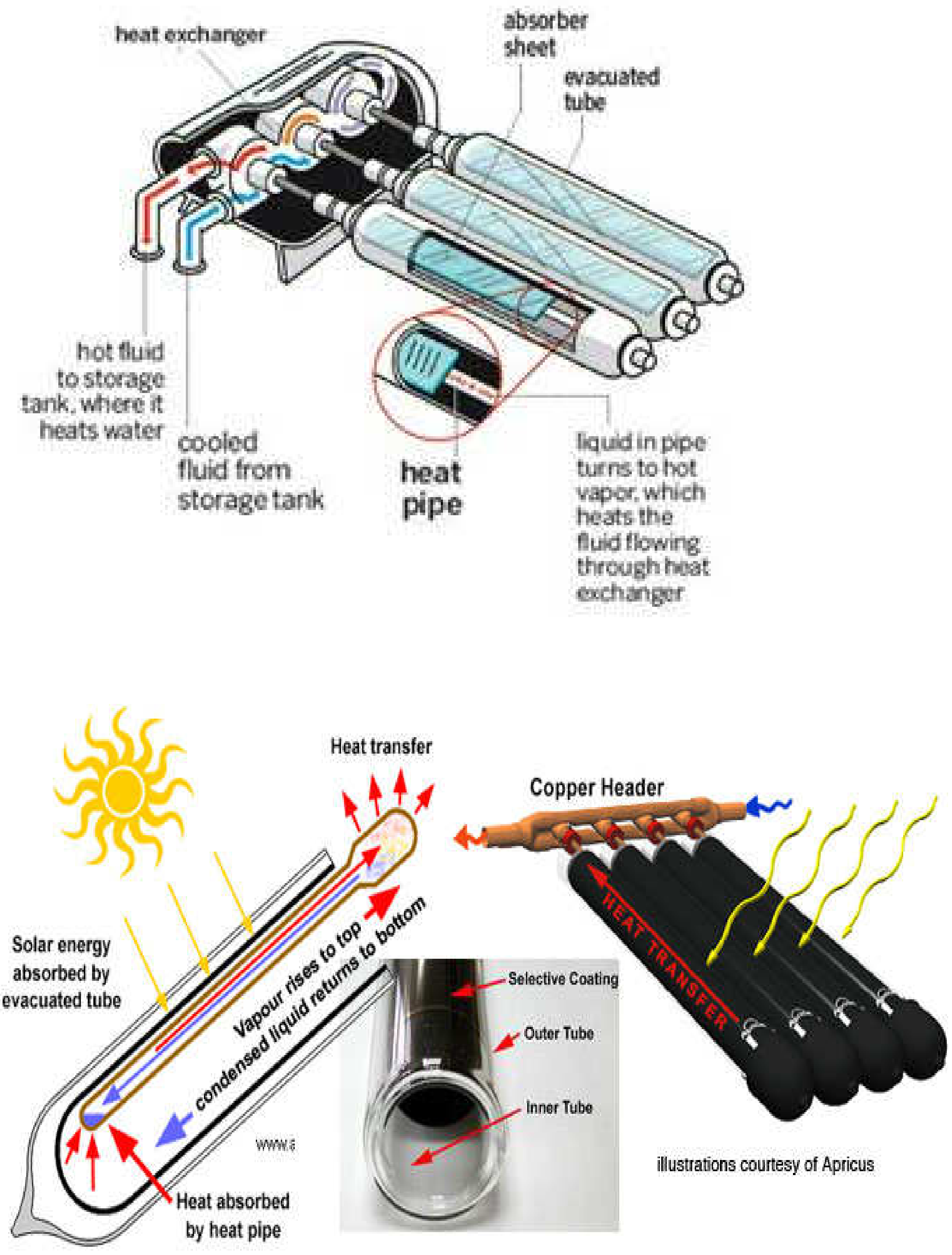


Figure 3.4.7. *Heat pipe evacuated-tube collectors* ***(****integral collector-storage (ICS))*
http://www.altdotenergy.com/wp-content/uploads/2008/02/evacuated-tube-collectors.jpg

Collect more sunshine

A key benefit of the Evacuated Tubes used in Hills Solar Esteem hot water systems is that they are round. Therefore the tubes are always facing the sun and can absorb more of the sun's energy.

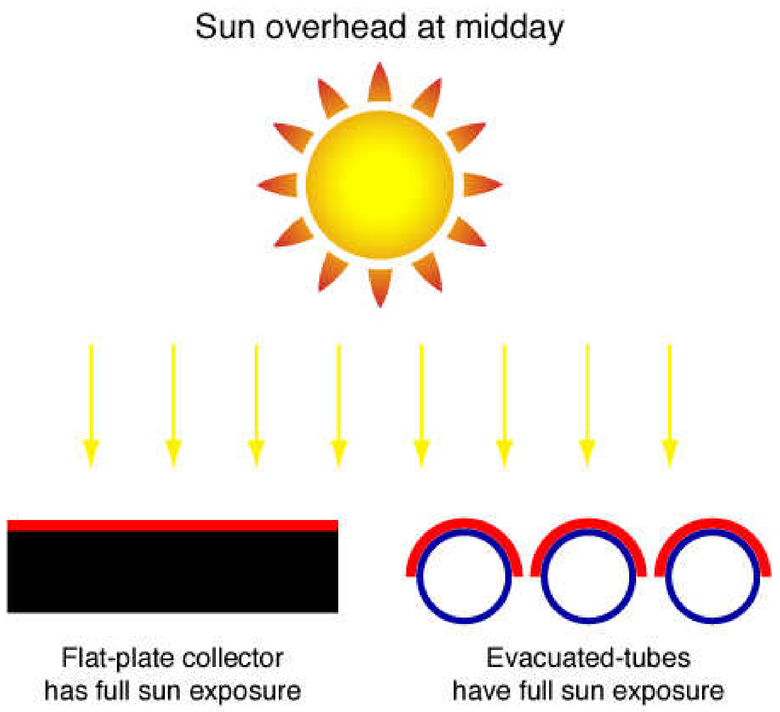


Figure 3.4.8. *Sun overhead at midday*
http://www.alternative-renewable-energy-solutions.com/evacuated-tubes-vs-flat-plates

In contrast, flat-plate collectors only achieve their maximum efficiency in the middle of the day. A great deal of the sun's energy is simply reflected off the flat glass panels, especially in the morning and afternoon. The cylindrical design of the tubes ensures effective collection of the Sun's thermal energy throughout the day.

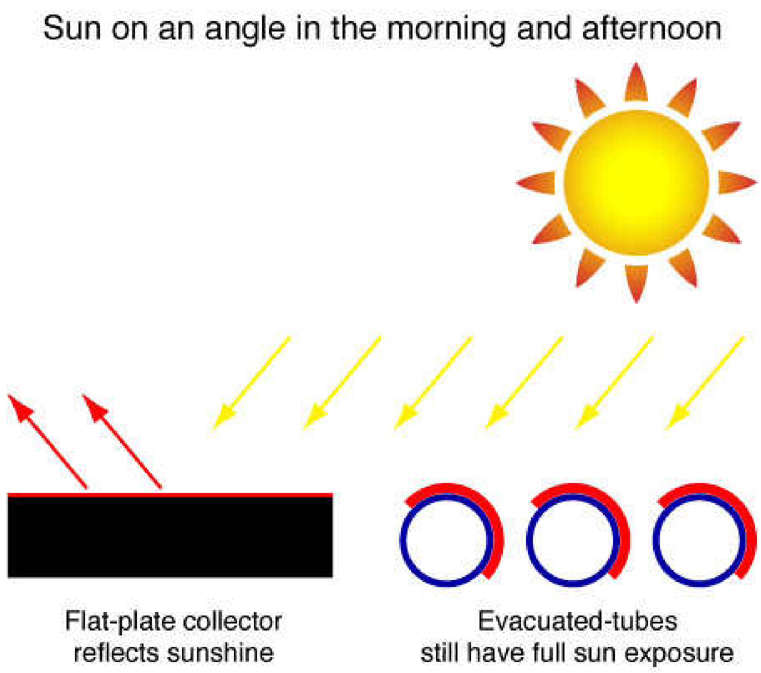


Figure 3.4.9. *Sun on an angle in the morning and afternoon* [*http://www.alternative-renewable-energy-solutions.com/evacuated-tubes-vs-flat-plates*](http://www.alternative-renewable-energy-solutions.com/evacuated-tubes-vs-flat-plates)

However, evacuated-tube collectors are more expensive than flat-plate collectors, with unit area costs about twice that of flat-plate collectors.

3.4.6. Water heating methods and different solutions

Thermosyphon system

For storing water overnight or on cloudy days, a storage tank is needed. A very simple way of doing this, making use of gravity is shown in Figure 3.4.10 - the thermosyphon system. The principle of the thermosyphon system is that cold water has a higher specific density than warm water, and so being heavier will sink down. Therefore, the collector is always mounted below the water storage tank, so that cold water from the tank reaches the collector via a descending water pipe. If the collector heats up the water, the water rises again and reaches the tank through an ascending water pipe at the upper end of the collector. The cycle of tank–water pipe–collector ensures the water is heated up until it achieves an equilibrium temperature. The consumer can then make use of the hot water from the top of the tank, with any water used is replaced by cold water at the bottom. The collector then heats up the cold water again. Due to higher temperature differences at higher solar irradiances, warm water rises faster than it does at lower irradiances. Therefore, the circulation of water adapts itself almost perfectly to the level of solar irradiance. A thermosyphon system’s storage tank must be positioned well above the collector, otherwise the cycle can run backwards during the night and all the water will cool down. Furthermore, the cycle does not work properly at very small height differences. In regions with high solar irradiation and flatroof architecture, storage tanks are usually installed on the roof.

Thermosyphon systems operate very economically as domestic water heating systems, and the principle is simple, needing neither a pump nor a control. However, thermosyphon systems are usually not suitable for large systems, that is, those with more than 10 m^2 of collector surface. Furthermore, it is difficult to place the tank above the collector in buildings with sloping roofs, and single-circuit thermosyphon systems are only suitable for frost-free regions.

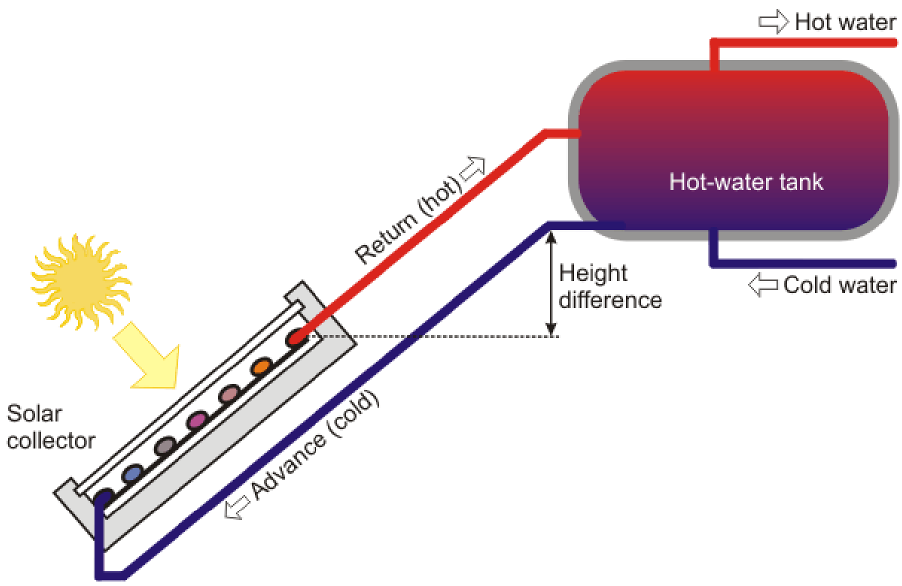


Figure 3.4.10 *Thermosyphon systems*
http://www.volker-quaschning.de/articles/fundamentals4/index.php

Forced-circulation systems

In contrast to thermosyphon systems, an electrical pump can be used to move water through the solar cycle of a system by forced circulation. Collector and storage tank can then be installed independently, and no height difference between tank and collector is necessary. Figure 3.4.11 shows a system using forced circulation with a conventional boiler for back-up heating.

Two temperature sensors monitor the temperatures in the solar collector and the storage tank. If the collector temperature is above the tank temperature by a certain amount, the control starts the pump, which moves the heat transfer fluid in the solar cycle; ‘switch-on’ temperature differences are normally between 5°C and 10°C. If the temperature difference decreases below a second threshold, the control switches off the pump again.

In regions where there is a danger of frost, a double-circuit system is usually used. Drinking water is kept inside the storage tank, while the water in the solar cycle is mixed with an antifreeze agent. A heat exchanger transfers the heat of the solar cycle to the storage tank, and keeps the drinking water separate from the antifreeze mixture.

Forced-circulation systems can also be used for room heating as well as domestic water heating. In this case, collectors and storage tanks must be much larger than with simple domestic water heating systems, where a collector surface of about 4 m^2 is sufficient for most households. Larger systems have also been realized successfully with two or more storage tanks.

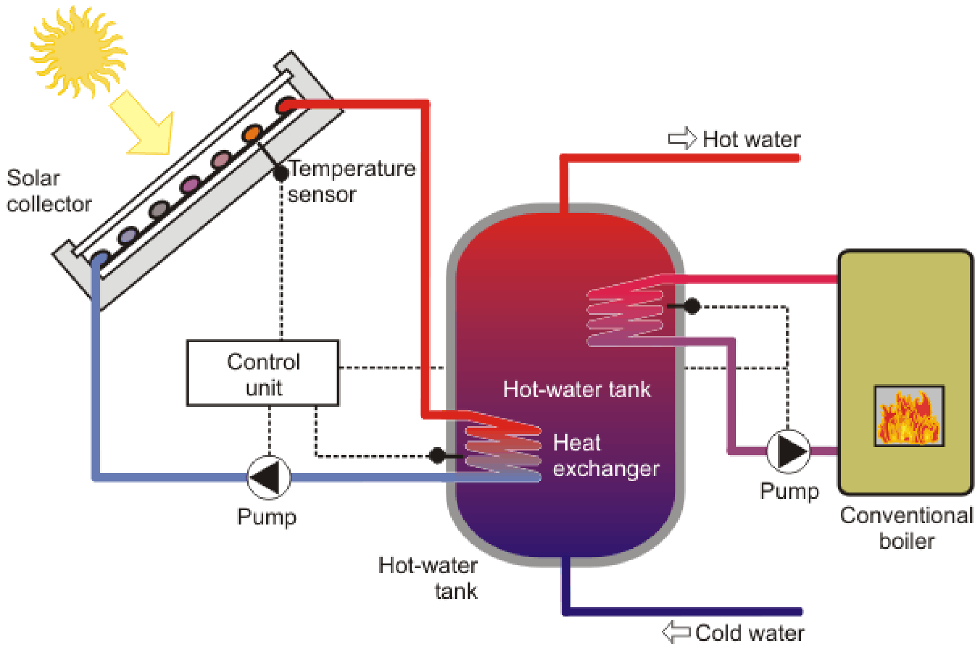


Figure 3.4.11. Forced-circulation systems
http://www.volker-quaschning.de/articles/fundamentals4/index.php

Active systems with drainback

A drain-back system is an indirect active system where heat transfer fluid circulates through the collector, being driven by a pump. However the collector piping is not pressurised and includes an open drainback reservoir. If the pump is switched off, all the heat transfer fluid drains into the drainback reservoir and none remains in the collector. Consequently the collector cannot be damaged by freezing or overheating. This makes this type of system well-suited to colder climates.

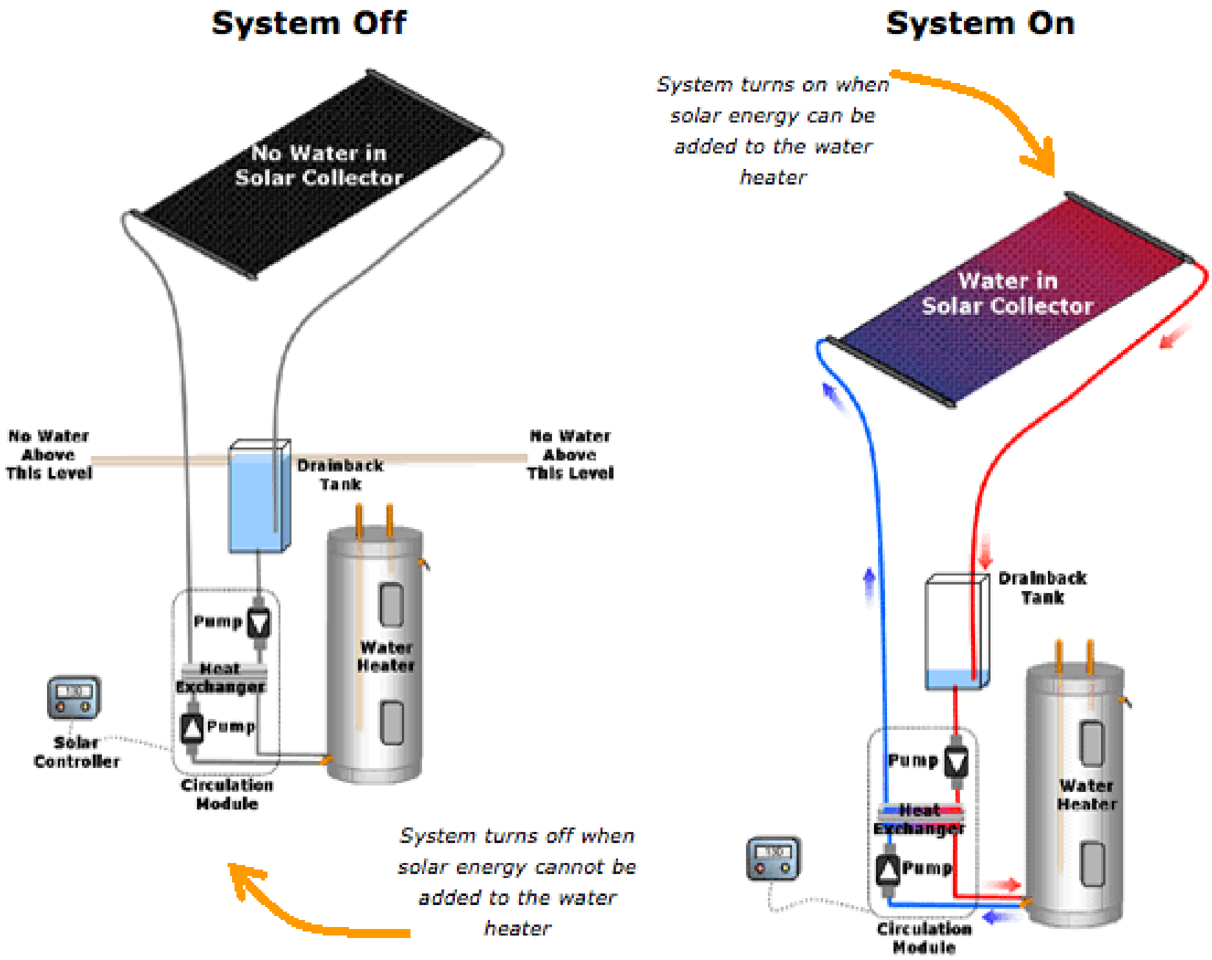


Figure 3.4.12. *Active drain back system*
http://www.gogreenwithsun.com/images/dual-solar-panels-sm.jpg

3.4.7. Controls

The heart of an active solar energy system is the automatic temperature control. Numerous studies and reports of operational systems show that faulty controls are usually the cause of poor solar system performance. Reliable controllers are available, and with proper understanding of each system function, proper control systems can be designed. In general, control systems should be simple; additional controls are not a good solution to a problem that can be solved by better mechanical design. The following key considerations pertain to control system design:

- Collector sensor location/selection
- Storage sensor location
- Over-temperature sensor location
- On-off controller characteristics
- Selection of reliable solid-state devices, sensors, controllers, etc.
- Control panel location in heated space
- Connection of controller according to manufacturer’s instructions
- Design of control system for all possible system operating modes, including heat collection, heat rejection, power outage, freeze protection, auxiliary heating, etc.
- Selection of alarm indicators for pump failure, low temperatures, high temperatures, loss of pressure, controller failure, nighttime operation, etc.

The following control categories should be considered when designing automatic controls for solar energy systems:

- Collection to storage
- Storage to load
- Auxiliary energy to load
- Alarms
- Miscellaneous (e.g., for heat rejection, freeze protection, draining, and over-temperature protection)

3.4.8. Differential temperature controller (DTC)

Most controls used in solar energy systems are similar to those for HVAC systems. The major exception is the differential temperature controller (DTC), which is the basis of solar energy system control. The DTC is a comparing controller with at least two temperature sensors that controls one or several devices. Typically, the sensors are located at the solar collectors and storage tank (Figure 3.4.13). On unpressurized systems, other DTCs may control the extraction of heat from the storage tank.

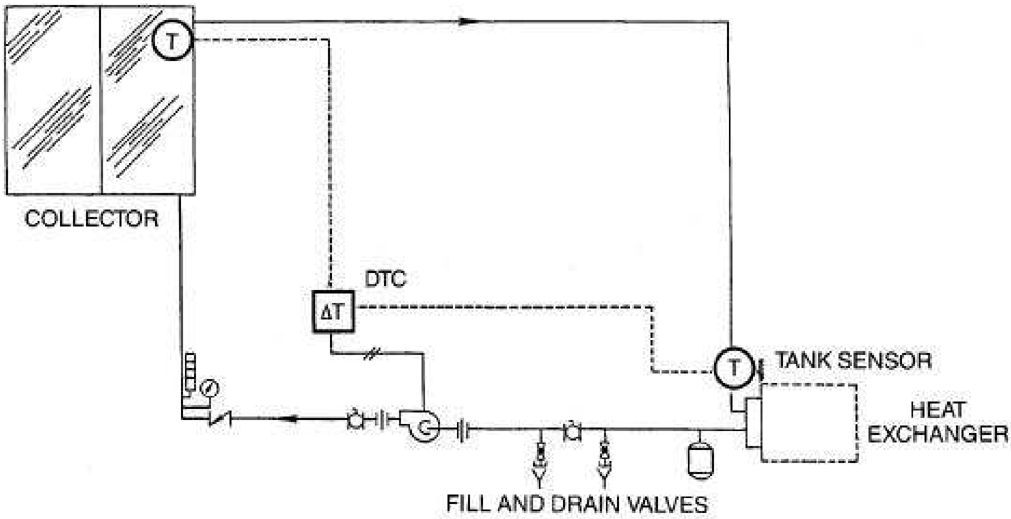


Figure 3.4.13. *Basic Nonfreezing Collector Loop for Building Service Hot Water Heating-Nonglycol Heat Transfer Fluid*
1998, 1999, 2000, and 2001 ASHRAE Handbook CD, Chapter 33

The DTC monitors the temperature difference, and when the temperature of the panel exceeds that of the storage by the predetermined amount (generally 4.5 to 11 K), the DTC switches on the actuating devices. When the temperature of the panel drops to 1.5 to 5.5 K above the storage temperature, the DTC, either directly or indirectly, stops the pump. Indirect control through a control relay may operate one or more pumps and possibly perform other control functions, such as the actuation of control valves.

The manufacturer's predetermined set point of the DTC may be adjustable or fixed. If the controller set point is a fixed temperature differential, the controller selected should correspond to the requirements of the system. An adjustable differential set point makes the controller more flexible and allows it to be adjusted to the specific system. The optimum *off* temperature differential should be the minimum possible; the minimum depends on whether there is a heat exchanger between the collectors and storage.

If the system requires a heat exchanger, the energy transferred between two fluids raises the differential temperature set point. The minimum, or *off*, temperature differential is the point at which pumping the energy costs as much as the value of the energy being pumped. For systems with heat exchangers, the *off* set point is generally between 3 and 5.5 K. If the system does not have a heat exchanger, a range of 1.5 to 3.5 K is acceptable for the *off* set point. The heat lost in the piping and the power required to operate the pump should also be considered.

The optimum differential *on* set point is difficult to calculate because of the changing variables and conditions. Typically, the *on* set point is 5.5 to 8.5 K above the *off* set point. The optimum *on* set point is a balance between optimum energy collection and avoiding short cycling of the pump.

3.4.9. Over-temperature protection

Overheating may occur during periods of high insolation and low load; thus, all portions of the solar energy system require protection against overheating. Liquid expansion or excessive pressure may burst piping or storage tanks, and steam or other gases within a system may restrict the liquid flow, making the system inoperable. Glycols break down and become corrosive if subjected to temperatures greater than 115°C. The system can be protected from overheating by

- stopping circulation in the collection loop until the storage temperature decreases;
- discharging the overheated water from the system and replacing it with cold makeup water;
- using a heat exchanger coil as a means of heat rejection to ambient air.

The following questions should be answered to determine whether over-temperature protection is necessary.

1. Is the load ever expected to be off, such that the solar input will be much higher than the load? The designer must determine possibilities based on the owner's needs and a computer analysis of system performance.
2. Do individual components, pumps, valves, circulating fluids, piping, tanks, and liners need protection? The designer must examine all components and base the over-temperature protection set point on the component that has the lowest specified maximum operating temperature. This may be a valve or pump with an 80 to 150°C maximum operating temperature. Sometimes, this criterion may be met by selecting components capable of operating at higher temperatures.
3. Is the formation of steam or discharging boiling water at the tap possible? If the system has no mixing valve that mixes cold water with the solar-heated water before it enters the tap, the water must be maintained below boiling temperature. Otherwise, the water will flash to steam as it exits the tap and, most likely, scald the user. Some city codes require a mixing valve to be placed in the system for safety.

Differential temperature controllers are available that sense over temperature. Depending on the controller used, the sensor may be mounted at the bottom or the top of the storage tank. If it is mounted at the bottom of the tank, the collector-to-storage differential temperature sensor can be used to sense over-temperature. Input to a DTC mounted at the top of the tank is independent of the bottom mounted sensor, and the sensor monitors the true high temperature.

The normal action taken when the DTC senses an over-temperature is to turn off the pump to stop heat collection. After the panels in a drain-back system are drained, they attain stagnation temperatures. While drain-back is not desirable, the panels used for these systems should be designed and tested to withstand over-temperature. In addition, drain-back panels should withstand the thermal shock of start-up when relatively cool water enters the panels while they are at stagnation temperatures. The temperature difference can range from 40 to 170 °C. Such a difference could warp panels made with two or more materials of different thermal expansion coefficients. If the solar panels cannot withstand the thermal shock, an interlock should be incorporated into the control logic to prevent this situation. One method uses a high-temperature sensor mounted on the collector absorber that prevents the pump from operating until the collector temperature drops below the sensor set point.

If circulation stops in a closed-loop antifreeze system that has a heat exchanger, high stagnation temperatures will occur. These temperatures could break down the glycol heat transfer fluid. To prevent damage or injury due to excessive pressure, a pressure relief valve must be installed in the loop, and a means of rejecting heat from the collector loop must be provided. The section on Hot Water Dump describes a common way to relieve pressure. Pressure increases due to the thermal expansion of any fluid; when water-based absorber fluids are used, pressure builds up from boiling.

The pressure relief valve should be set to relieve at or below the maximum operating pressure of any component in the closed-loop system. Typical settings are around 350 kPa (gage), corresponding to a temperature of approximately 150°C. However, these settings should be checked. When the relief valve does open, it discharges expensive antifreeze solution. Glycol antifreeze damages many types of roof membranes. The discharge can be piped to large containers to save the antifreeze, but this design can create dangerous conditions because of the high pressures and temperatures involved.

If a collector loop containing glycol stagnates, chemical decomposition raises the fusion point of the liquid, and freezing becomes possible. An alternate method continues fluid circulation but diverts the flow from storage to a heat exchanger that dumps heat to the ambient air or other sink (Figure 3.4.14). This wastes energy, but it protects the system. A sensor on the solar collector absorber plate that turns on the heat rejection equipment can provide control. The temperature sensor set point is usually 95 to 120°C and depends on the system components. When the sensor reaches the high-temperature set point, it turns on pumps, fans, alarms, or whatever is necessary to reject the heat and warn of the over-temperature. The dump continues to operate until the over-temperature control in the collector loop DTC senses an acceptable drop in tank temperature and is reset to its normal state.

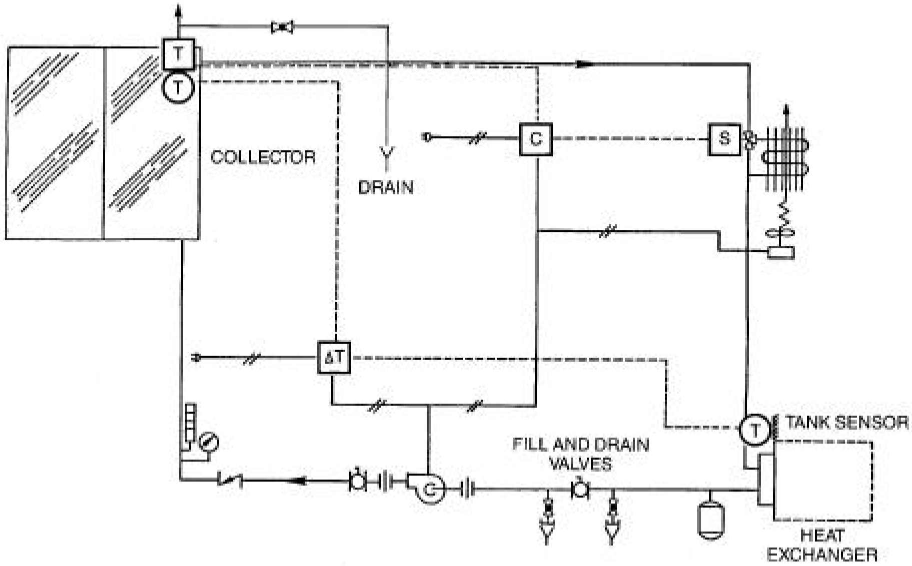


Figure 3.4.14. *Heat Rejection from Nonfreezing System Using Liquid-to-Air Heat Exchanger*
1998, 1999, 2000, and 2001 ASHRAE Handbook CD, Chapter 33

3.4.10. Hot water dump

If water temperatures above 95°C are allowed, the standard temperature-pressure (99°C, 860 kPa) safety relief valve may operate occasionally. If these temperatures are reached, the valve opens, and some of the hot water vents out. However, these valves are designed for safety purposes, and after a few openings, they leak hot water. Thus, they should not be relied on as the only control device. An aquastat that controls a solenoid, pneumatic, or electrically actuated valve should be used instead.

3.4.11. District heating system

A district heating system distributes thermal energy from a central source to residential, commercial, and/or industrial consumers for use in space heating, cooling, water heating, and/or process heating. The energy is distributed by steam or hot water lines. Thus, thermal energy comes from a distribution medium rather than being generated on site at each facility.

Whether the system is a public utility or user owned, such as a multi-building campus, it has economic and environmental benefits depending somewhat on the particular application. Political feasibility must be considered, particularly if a municipality or governmental body is considering a district heating installation. Historically, successful district heating systems have had the political backing and support of the community.

Applicability

District heating systems are best used in markets where

- the thermal load density is high
- the annual load factor is high.

A high load density is needed to cover the capital investment for the transmission and distribution system, which usually constitutes most of the capital cost for the overall system, often ranging from 50 to 75% of the total cost for district heating systems (normally lower for district cooling applications).

The annual load factor is important because the total system is capital intensive. These factors make district heating systems most attractive in serving

- industrial complexes
- densely populated urban areas
- high-density building clusters with high thermal loads

Low-density residential areas have usually not been attractive markets for district heating, although there have been some successful applications. District heating is best suited to areas with a high building and population density in relatively cold climates. District cooling applies in most areas that have appreciable concentrations of cooling loads, usually associated with tall buildings.

Components

District heating and cooling systems consist of three primary components:

- the central plant
- the distribution network
- the consumer systems

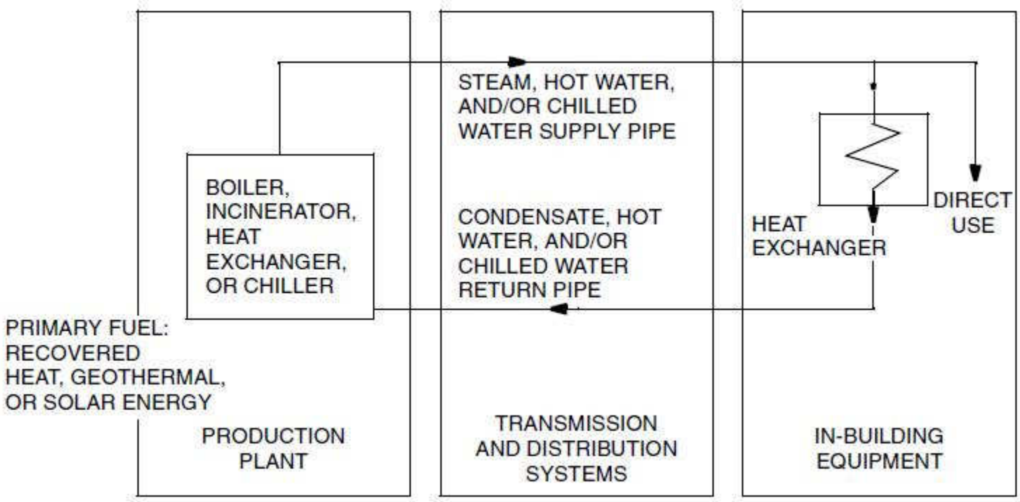


Figure 3.4.15. *Major Components of District Heating System*
1998, 1999, 2000, and 2001 ASHRAE Handbook CD, Chapter 11

The **central source** or **production plant** may be any type of boiler, a refuse incinerator, a geothermal source, solar energy, or thermal energy developed as a by-product of electrical generation. The last approach, called cogeneration, has a high energy utilization efficiency

The second component is the **distribution** or **piping network** that conveys the energy. The piping is often the most expensive portion of a district heating or cooling system. The piping usually consists of a combination of preinsulated and field-insulated pipe in both concrete tunnel and direct burial applications. These networks require substantial permitting and coordinating with nonusers of the system for right-of-way if not on the owner's property. Because the initial cost is high, it is important to optimize use.

The third component is the **consumer system**, which includes in-building equipment. When steam is supplied,

- it may be used directly for heating;
- it may be directed through a pressure-reducing station for use in low pressure (0 to 100 kPa) steam space heating, service water heating, and absorption cooling;
- it may be passed through a steam-to-water heat exchanger.

When hot water is supplied, it may be used:

- directly by the building systems;
- **isolated by a heat exchanger.**

3.4.12. Benefits of district heating system

Environmental Benefits

Emissions from central plants are easier to control than those from individual plants. A central plant that burns high- sulphur coal can economically remove noxious sulphur emissions, where individual combustors could not. Similarly, the thermal energy from municipal wastes can provide an environmentally sound system. Cogeneration of heat and electric power allows for combined efficiencies of energy use that greatly reduce emissions and also allow for fuel flexibility.

Consumer Economic Benefits

A district heating and cooling system offers the following economic benefits. Even though the basic costs are still borne by the central plant owner/operator, because the central plant is large the customer can realize benefits of economies of scale.

Operating Personnel. One of the primary advantages to a building owner is that operating personnel for the HVAC system can be reduced or eliminated. Most municipal codes require operating engineers to be on site when high-pressure boilers are in operation. Some older systems require trained operating personnel to be in the boiler/mechanical room at all times. When thermal energy is brought into the building as a utility, depending on the sophistication of the building HVAC controls, there may be opportunity to reduce or eliminate operating personnel.

Insurance. Both property and liability insurance costs are significantly reduced with the elimination of a boiler in the mechanical room since risk of a fire or accident is reduced.

Usable Space. Usable space in the building increases when a boiler and related equipment are no longer necessary. The noise associated with such in-building equipment is also eliminated. Although this space usually cannot be converted into prime office space, it does provide the opportunity for increased storage or other use.

Equipment Maintenance. With less mechanical equipment, there is proportionately less equipment maintenance, resulting in less expense and a reduced maintenance staff.

Higher Thermal Efficiency. A larger central plant can achieve higher thermal and emission efficiencies than can several smaller units. When strict regulations must be met, additional pollution control equipment is also more economical for larger plants. Cogeneration of heat and electric power results in much higher overall efficiencies than is possible from separate heat and power plants. Partial load performance of central plants may be more efficient than that of many isolated small systems because the larger plant can operate one or more capacity modules as the combined load requires and can modulate output. Central plants generally have efficient base-load units and less costly peaking equipment for use in extreme loads or emergencies.

3.4.13. Heat exchanger

HEAT EXCHANGERS transfer heat from one fluid to another without the fluids coming in direct contact with each other. Heat transfer occurs in a heat exchanger when a fluid changes from a liquid to a vapour (evaporator), a vapour to a liquid (condenser), or when two fluids transfer heat without a phase change. The transfer of energy is caused by a temperature difference.

3.4.14. Plate heat exchangers

Plate heat exchangers consist of metal plate pairs arranged to provide separate flow paths (channels) for two fluids. Heat transfer occurs across the plate walls. The exchangers have multiple channels in series that are mounted on a frame and clamped together. The rectangular plates have an opening or port at each corner. When assembled the plates are sealed such that the ports provide manifolds to distribute fluids through the separate flow paths. Figure 8 illustrates the flow paths.

The multiple plates, called a **plate pack**, are supported by a carrying bar and contained by pressure plates at each end. The design of the carrying bar and pressure plate permit the units to be opened for maintenance or the addition or removal of plate pairs. The adjoining plates are gasketed, welded, or brazed together.

Gasketed plate heat exchangers are typically limited to design pressures of 2MPa. The type of gasketmaterial used limits the operating temperature. Brazed plate units are designed for pressures up to 3 MPa and temperatures up to 260°C.

Gasketed. The most common plate heat exchanger is the gasketed plate unit. Typically, nitrile butyl rubber (NBR) gaskets are used in applications up to 110°C. Ethylene-propylene terpolymer (EPDM) gaskets are available for temperatures up to 160°C. The gaskets are glued or clipped onto the plates. The gasket pattern on each plate creates the counterflow paths illustrated in Figure 3.4.16.

Welded. Two plates can be welded together at the edges into an assembly called a **cassette**. This flow channel contains fluids when appropriate gasketmaterial is not available such as for handling corrosive fluids. The channels containing the non-aggressive fluids are sealed with standard gaskets. Welded units can also be used for refrigeration applications. Figure 3.4.17. shows the flow path of a welded plate heat exchanger.

Brazed. Brazed plate heat exchangers have neither gaskets nor frames. They consist of plates brazed together with a copper or nickel flux. This design can be a very cost-effective; however, the lack of maintenance access limits their application.

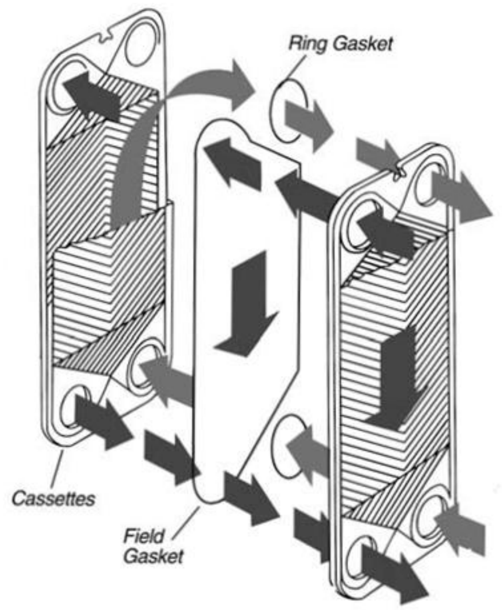


Figure 3.4.16. *Flow Path of Gasketed Plate Heat Exchanger*
1998, 1999, 2000, and 2001 ASHRAE Handbook CD, Chapter 43

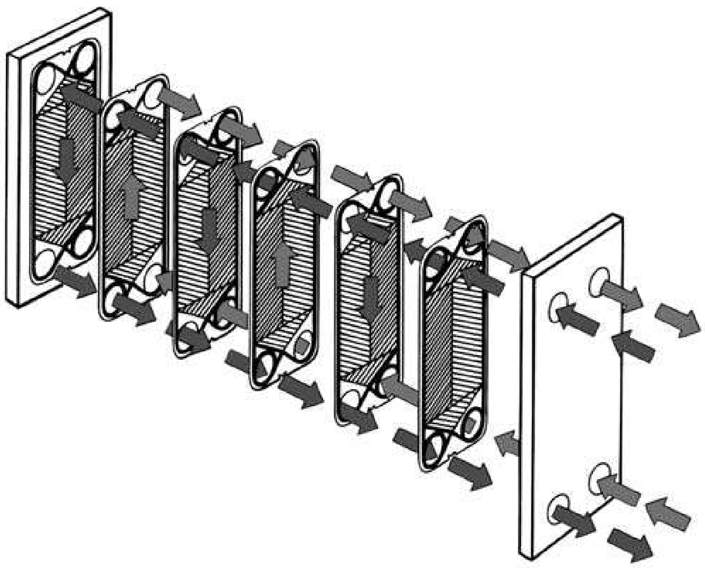


Figure 3.4.17. *Flow Path of Welded Plate Heat Exchanger*
1998, 1999, 2000, and 2001 ASHRAE Handbook CD, Chapter 43

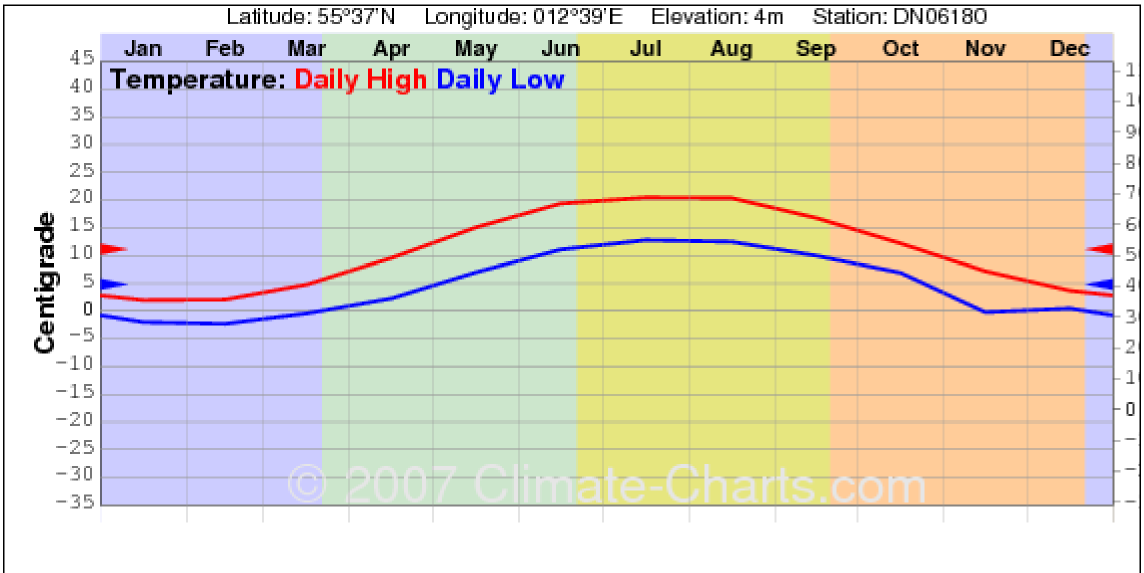
3.5.Solar electrical energy

For our project, we have separated in different parts the work. we worked about the choice for the solar panels photovoltaic and about better systems for the building. Before that, we looked for different piece of information about the weather in Denmark, the percentage of sunlight, the precipitations data or the daylight during one year. Once those data were collected, we were able to compute which panels is the best and how many KW.h we can get. We will finish by choosing the right lights and lamps and we will try to take advantage of this choice to save money. We will compare these lamps between advantages and disadvantages and some tables.

3.5.1. The weather

First of all, let’s try to find some data about the Denmark climate, because we need to know if it is possible to install solar panels PV and if we will have a good efficiency in this country. We found some documents and drawings about the weather.

Table 3.5.1 : *Denmark atmospheric temperatures*



http://www.climate-charts.com/Locations/d/DN06180.php

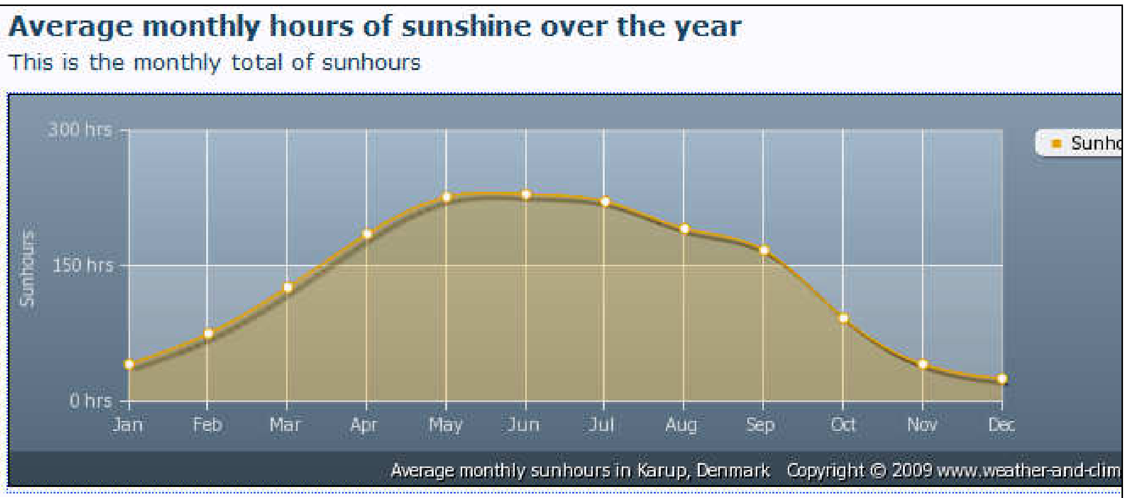
***Table 3.5.2 :** Average temperature in Denmark*

0101	Temperature Mean Value	C	.1	-.1	2.0	5.6	10.9	15.0	16.4	16.3	13.3	9.6	5.1	1.8
0201	High Temperature Mean Value	C	2.0	2.1	4.8	9.6	15.1	19.4	20.5	20.4	16.8	12.2	7.2	3.7
0301	Low Temperature Mean Value	C	-2.0	-2.3	-.4	2.3	7.0	11.1	12.8	12.5	10.0	6.9	-.2	.5

http://www.climate-charts.com/Locations/d/DN06180.php

We can see on this picture the average temperature in Denmark. The highest temperature is during the summer and it does not exceed 20 centigrades and the lowest is during winter and it is 0 °C or a little bit less. We don't need to have a high centigrade but with this diagram we can have an idea about the country.

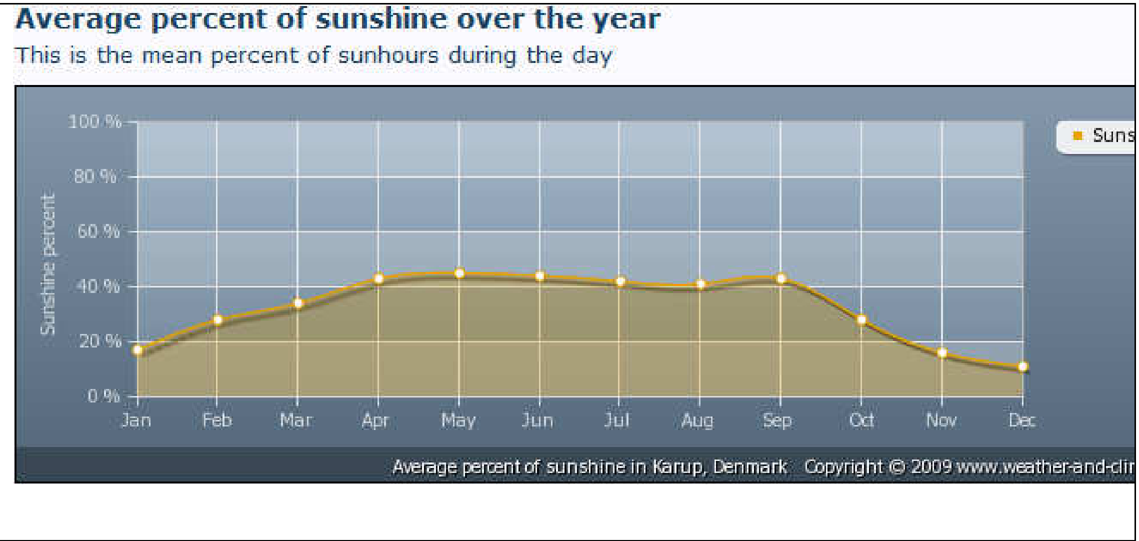
***Table 3.5.3 :** Sunshine in Denmark*



http://www.weather-and-climate.com/average-monthly-hours-Sunshine,Karup,Denmark

You can see on this table the sunshine over the year in hours. During spring and summer the solar panels can make more electricity than autumn and winter. In fact during this period the daylight is very important because we are in the north of Europe.

Table 3.5.4 : *Percent of sunshine*



http://www.weather-and-climate.com/average-monthly-percent-Sunshine,Karup,Denmark

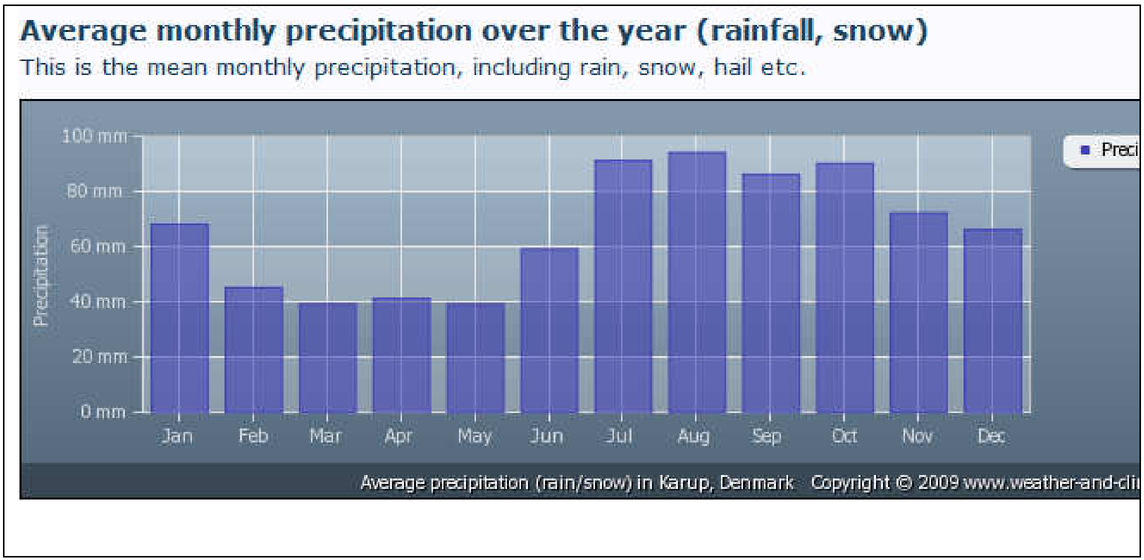
We can notice, in the picture below, we can see the percentage of the sunshine by months and we can calculate the average of the sun hours during the year :

(Jan + Feb + Mar + Apr……) / 12 = ?

(0,19 + 0,27 + 0,35 + 0,42 + 0,44 + 0,42 + 0,40 + 0,40 + 0,43 + 0,30 + 0,18 + 0,12) / 12 = 0,32

Therefore the total efficiency for one year in Denmark is 32,6 % of sunshine.

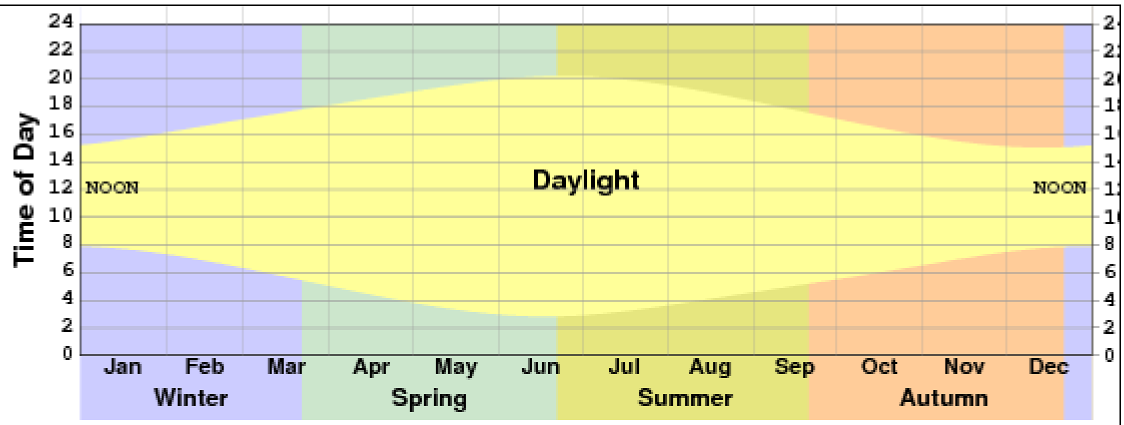
Table 3.5.5 : *Monthly precipitation*



http://www.weather-and-climate.com/average-monthly-precipitation-Rainfall,Karup,Denmark

For a low energy house we need to know if the precipitation rate in Denmark is high so that we could be able to recycle and use it for the housing water system. During the summer and winter the precipitations are important. So if we want to install a tank for that we can compute how many liters of waters we can stock.

Table 3.5.6 : *Time of daylight*



http://www.climate-charts.com/Charts/D/DN06180.png

This diagram highlights the amount of monthly daylight hours. This piece of information is crucial for the photovoltaic solar panels situation. Over the spring and summer there are on average 17 daylight hours. The temperature itself does not really matter because the sunlight is the only crucial element that makes work panels.

3.5.2. Solar Panels Photovoltaic

a.°) How are the Panels made ?

Definition :

A photovoltaic module or photovoltaic panel is an interconnected assembly of photovoltaic cells, also known as solar cells. It is then used as a component in a larger photovoltaic system to extend electricity for commercial and residential applications. A single photovoltaic module can only produce a limited amount of power, many installations contain several modules or panels and this is known as a photovoltaic array. A photovoltaic installation typically includes a range of photovoltaic modules or panels, an inverter, batteries (if you want to keep the electricity) and interconnection wiring. The solar panels photovoltaic are used with a lot of different systems such as satellites, approach lights or ticket machine. They use that because it is more expensive to connect these devices with the electrical communication.

Constitution :

The solar panels are composed of solar cells. Those cells convert the energy of sunlight directly into electricity by the photovoltaic effect. The solar cells are made with silicon and also semiconductor like indium, cadmium telluride and so on. The module is constituted of solar cells electrically connected and encapsulated. They have frequently a sheet of Glasson of the front side, to protect the semiconductor wafers from the natural elements and to pass the light.

Functioning :

Solar panels use light energy (photon) from the sun to generate electricity. The current received depends on the incidence of the reflected light. The sunlight photon hit the solar panel and are absorbed by semiconducting materials like silicon. The Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Then the solar cells convert into a usable amount of direct current (DC) electricity. To use or sell the electricity, you need to buy a converter to spin off the direct current into an alternative current.

b.°) Dimensional of a photovoltaic system

➔ First step :

Normally, we have to know the requirements in tension, the power of appliance and the duration of use. But in our building we have 21 flats for families and 6 shops. On average the electric consumption was 1200 kwh / citizen. And for a couple with two children this consumption was between 2500 and 3100 kwh (without heating). For the shops, it is very difficult to find some data about the consumption because we don’t know what kinds of shop it is. we can’t estimate the consumption of heating and water between a pub or a hairdresser, but we think that there is a big difference between both.

So now we can do an appraisal for the flats and for 21 flats with approximately 3000 kwh of consumption, we have a total consumption of 63 000 kwh without the shops.

➔ Second step :

Then, we can calculate the amount of solar energy that we are going to save from the country and the site. We are in Denmark, precisely in Copenhagen and we found some information about this country. It is not a country with a lot of sunshine and high temperatures, so the coefficient of sunshine is 800 and in average it is 1000 for example in France. The unit is watt / m². After, we have to find an optimal angle for the solar panels PV and the orientation.

➔ Third step :

Now, we have to choose what kind of photovoltaic solar panels we want to use, and the reason why we took this one. To select one, different factors have to be taken into consideration such as efficiency, the power, the size or if it is a monocrystalline or polycrystalline. There are some differences between both (advantages and disadvantages).

- Concerning the monocrystalline, there is a good efficiency (14% at 16%), a lot of producers and a good proportion between power and area. But it is expensive to built this kind of panels.
- Concerning the polycrystalline, there is a good efficiency for converting the electricity (about 100Wc/m²), it is less expensive than

monocrystalline and the cells are square which is better in the module. But it does not work very well when there is not a lot of sunshine.

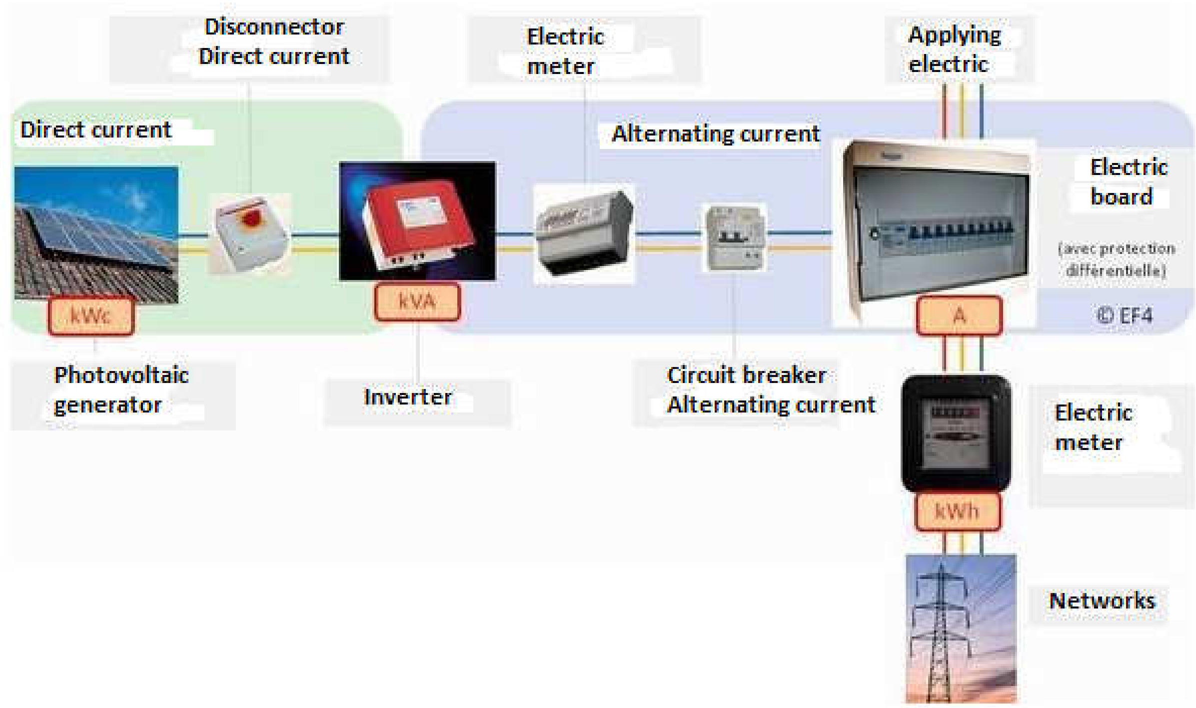
➔Fourth step :

Now, we can think about how to install the solar panels with the electric part.

- First , we try to know take if we want to sell the electricity at the electrical communication :

With this installation we can sell the electricity and find all of the different devices.

Picture 3.5.1 : *System fir sell electricity*



We have at the beginning a group of photovoltaic solar panels, then we can use a disconnecting switch. This one can isolate the photovoltaic generator electrically. We have to convert the direct current to alternating current. This transformation is realize by an inverter. The unit is Kilovoltampere (KVA). Outside of the inverter, there is an applying electric which are connect both. Of course, there are some circuit breakers and switch to isolate and protect each electric circuit.

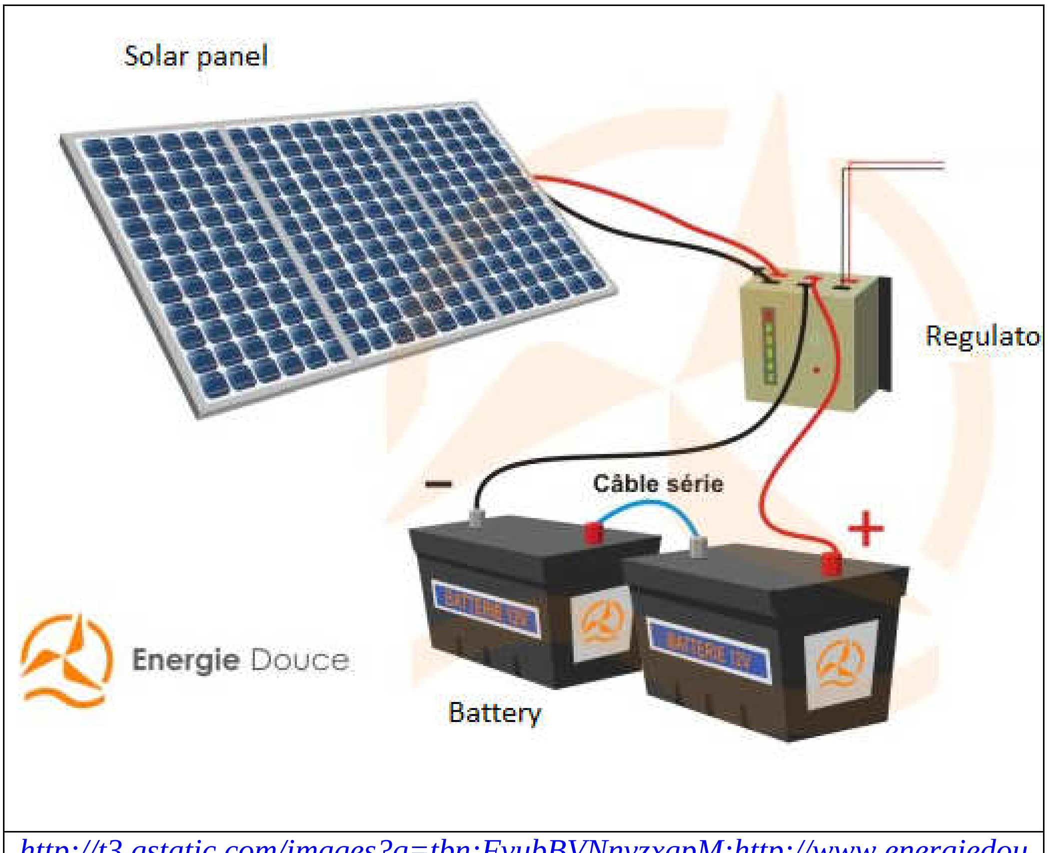
The electricity is buying by the national company in Denmark and here the price for 1 Kwh is 2 DKK or 0,24 €.

For our installation, if we can get 10,168 Kwh and if we want to buy all of the electricity

10.168 x 2 = 20336 DKK therefore 2733 Euros.

- In secondly, If want to keep the energy and we have to take a battery for stocking the electricity. Also the system is the same but you need to add a load regulator for stabilizing the solar energy and protecting the battery against the overloads. So we have to use a semi-stationary battery at slow-shock, with the solar panel system. This one can abide 500 to 600 cycles. On average, the life span can be 5 years.

Picture 3.5.2 : *System for keeping electricity*



[*http://t3.gstatic.com/images?q=tbn:FvubBVNnvzxgpM:http://www.energiedouce.com/media/docs/Energiedouce-schema-installation-panneau-solaire-24-volts-sans-convertisseur.jpg*](http://t3.gstatic.com/images?q=tbn:FvubBVNnvzxgpM:http://www.energiedouce.com/media/docs/Energiedouce-schema-installation-panneau-solaire-24-volts-sans-convertisseur.jpg)

At the end of the installation, we are going to choose the panel structure, It is mean the size of the structure so that the panels will be in conformity with the structure.

Picture 3.5.3 : *Structure of the panel*

	
http://pagesperso-orange.fr/energies-nouvelles-entreprises/images/strct1.jpg	

The price :

We have about 101,68 square meters solar panels and the price for 1 square meter is 1000 € (7440DKK). we can calculate for my installation, it is around 101680 €, it is very expensive but you could have some financial help by the government.

3.6.The Lamps

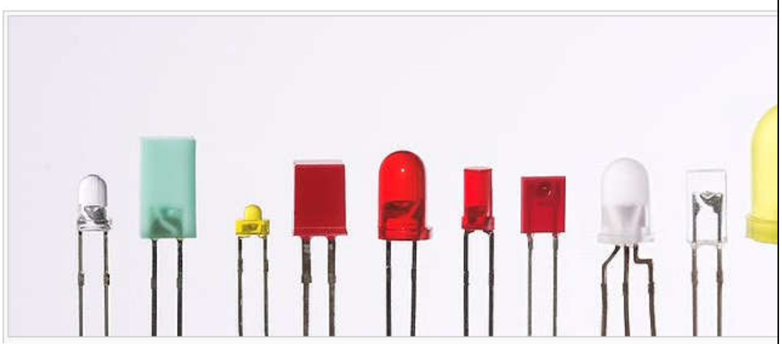
We want to choose the best lamps for economize energy and save the environment. For that we need to know the different advantages and disadvantages between the kinds of lamps and why you can put a LED in the kitchen for example and not in the living-room.

1.°) Comparing the different kinds of Lamps

- In first , we are going to describe the LED (light-emitting diode), this one is one of the best lamp actually. The life time is exceptional (50 at 100.000 hours). The LED is very fast and hard-wearing. You can switch off and switch on the lamp and is not damage. They have a variable luminance and you can use a dimmer. They are small and they are available in low voltage. Finally you can put this kind of lamp outside or inside and it is very useful. But there are some disadvantages like, the price is high, the colour is not perfect and it is difficult to find LED with a full power.

Picture 3.6.1 : *Kinds of LEDs*

Types



http://upload.wikimedia.org/wikipedia/commons/thumb/9/9e/Verschiedene_LEDs.jpg/750px-Verschiedene_LEDs.jpg

- Secondly, we are going to describe the Compact Fluorescent Lamp. For this one there are more disadvantages than the LED. The life time is good about 10 at 20 thousand hours. The energy efficiency is very good, the lamp stay warm after use. You can find a lot of different power for this kind of lamp. Although The price is little bit expensive but less than LED, the colour is not very good above all the beginning (when you switch on the lamp). The size of this lamp is big, you cannot use everywhere. This lamps are make with dangerous matter (mercury, lead). They are pretty breakable so you have to be careful and you cannot use with a dimmer. They do not like when you switch of the lamp all time, you can damage the lamp.

Picture 3.6.2 : *Kind of Compact fluorescent lamp*

http://upload.wikimedia.org/wikipedia/commons/thumb/0/0f/CompactFluorescentLightBulb.jpg/200px-CompactFluorescentLightBulb.jpg

- Thirdly, we are going to describe the last lamp, Incandescent light bulb. This one is the best known and maybe the most use. But now we can compare with different lamps and this one is very bad. They are some advantages like the price is very cheap when you compare with the others lamps. There are a lot of different sizes and the colour is very good. The gas inside the lamp is clean. But the life time is very bad, no more than one thousand hours, the lamp is very breakable and the efficiency is very bad, there are a lot of heat and it could be dangerous.

Picture 3.6.3 : *Incandescent light bulb*

http://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Gluehlampe_01_KMJ.png/200px-Gluehlampe_01_KMJ.png

3.7. Automatics at house

When think about how the house of the future will be, predictions we obtain are really different. But the real innovations will occur in the interior of homes and have their origin in the application of computers in the same, so in the coming decades will not miss us find ourselves in a situation like that follows: Enter the house and that automatically lights up the rooms that we crossed, turn on the stereo system with your favorite radio station, enter in a bath previously heated and placed under running water warm shower. Throughout this sequence no one has neither triggered a switch nor pressed any buttons. It is domotics, or set of housing services by systems that perform multiple functions, which can be connected together internal and external networks and communications, thanks to all of which get a considerable saving of energy, effective technical management of housing, good communication with the outside and a high level of security.

In fact according to Xavier Passaret, automation expert engineer who headed the technical services unit of the Institut Cerdà Barcelona, before became the General Director of Delta Dore Electrónica S.A., “The house of the future will be very similar to the present, a home automation system which will provide more comfort and more safety and shall be conditioned to be more respectful of the environment.”

The possibilities of home automation will be or are almost endless and allow a completely customized package of services adapted to the inhabitants of the house. The technology will enable the house of the future is, therefore, all comfortable, safe and effective that users can imagine and of course pay.

3.7.1. Features of smart housing

In general, a home automation system have a network of communication and dialogue to enable the interconnection of a number of teams to information about the home environment, and based on it, to conduct certain actions on that environment. Thus the fundamental characteristics of this system are:

a) Remote control from inside the house.

Such a possibility is achieved through a system of communication among different computers that are part of the home.

The most immediate consequence of the above is a considerable reduction of the need to move within the housing, which may be particularly important for people in the elderly or disabled

b) Remote control from outside the home.

It presupposes a change in schedules in which domestic tasks are performed and allows users to make better use of your time. At present there are already numerous appliances that incorporate this aspect, for example Margherita 2000 washing machine by Ariston Digital that can be handled by the Internet.

Picture 3.7.1.- *Margherita 2000 washing machine by Ariston*
http://www.destek-yazilim.com/Galeri/Merloni.htm

c) Pre-programmed.

Allows systems to be programmed either to perform certain functions at the touch of a button or that undertaken in terms of other environmental conditions (time, indoor or outdoor temperature, etc.).

d) Access to external services.

Here we can include services as telebanking or teleshopping and teleworking course, but the former has been one of the main reasons for the application of new technologies to housing.

Contents of the system

Although as stated at the beginning is really hard to identify the limits of performance of the intelligent, far from home typical areas to which most directly affected is basically reduced to four:

a) Power: As the system manages power consumption by timers or timer.

b) The comfort: This includes heating, hot water, cooling or lighting.

c) Security: integrates three security fields that normally are controlled by different systems:

1. - Security of assets: Management of access control and presence, and even simulation of the latter.

2. - Security of people: Especially suitable for the elderly and sick.

3. - Incidents and Troubleshooting: Using sensors can detect fires and gas leaks and water.

d) Communications: Perhaps the main feature is the integration of home automation systems, so often see its interconnected to various devices such as telephone or video intercom.

3.7.2. Objectives

The objectives or handicaps that are presented to the automation in the short term, as we can distinguish two different perspectives: the user and the purely technical. In the first major goals are:

- Create the possibility of a installation before construction.
- To facilitate the expansion and introducing new features.
- Achieving greater simplicity of use as possible, which is particularly difficult if we take into account the complexity of the system.
- To a sufficient degree of standardization and implementation, allowing a significant reduction in their costs.
- Ensure complete customer service.

On the other side from the technical side, the main objective of an obvious smooth operation of the facility in general, passes to ensure sufficient transmission speed.

Home automation and ecology

The debate between high technology and ecology, between artificial and natural buildings, including smart homes and planners must take into account fools Mother Nature needs very specific conditions to regenerate. Besides all this and not only on the inner satisfaction that produces siding with environmental conservation, but also, in most cases, a medium-term economic interest.

As the title of our project show, it is about a low energy house. So after taking in mind all the systems that can been improved, it is compulsory to control them, in order to reduce to the max the energy consumption, taking advantage of all the systems installed and the natural resources that we have. This is why we are going to explain the automatics that are planning to install in our house.

3.7.3. Status of the global automation

Before start with our part in this project, is a good idea to know how the state of the art is around the world.

- United States.

The guidance given to the home automation into the home is basically interactive and was the first country, in 1984, to develop a home demotic standard: the CEBus (Consumer Electronic Bus), also known as **EIA-600**, in order to improve the home automation standard X10.

This standard have joined more than 17 American manufacturers (AT & T, Johnson, Tandy, Panasonic and others).

The CEBus standard was released in September 1992.

- Japan.

Unlike the Americans the trend is towards automated home to the interactive. The official surveys tell of a home automation market of DKK 6,253 billion in present figure.

- Europe.

The first initiative began in 1984 in six European companies. Information Society Technologies (IST) developed intensively between 87 and 88 some programs, leading finally to the current program ESPRIT (**European Strategic Program on Research in Information Technology**). The main objective of this program is to define a standard for the integration of home electronic systems and analyze which are the areas of application of a system of this kind. Thus a standard is sought to enable a move towards integrated applications of the house. They are currently represented in the ESPRIT all the countries of the European Union.

3.7.4. Introduction to our selection: Schneider Electric.

According to the test extracted from: http://mhmonline.com/green-material/news/steps-achieving-active-energy-management-1002/index2.html , wrote by David Voynow, a global specialist in energy management, who is market segment manager for material handling in the North American operating division of Schneider Electric, we can say that:

“The overall goal of an energy-efficient DC should be continuous improvement.

An EEM system can be especially effective in a warehouse or DC because it can track all forms of energy usage (water, compressed air, gas and steam, in addition to electricity). Additionally, many EEM systems can model energy efficiency, allowing users to normalize energy consumption based on various drivers, including volume of products being handled or outside air temperature, among others. EEM systems can also benchmark facilities against each other, so best practices can be identified and shared with under-performing facilities. A system could also be used to model one utility rate against another, or quantify payback on energy efficiency measures that are implemented.

Components like electronic motor starters have become robust enough to facilitate the flow of energy information that can lead to not only critical energy decision making, but also predictive maintenance. For example, a motor starter can monitor how much power each of a motor’s phases are using; if one phase becomes unbalanced, that information can be sent to the facility’s energy management or supervisory control and data acquisition (SCADA) system via PLC, which can calculate how much power is being used. If a motor is using more power than anticipated, it could mean that the motor is simply dirty and needs to be cleaned.

A strategic energy management plan should address both short-term improvements as well as future strategies to implement as energy prices fluctuate. A well considered plan should have clear actions in mind and reflect good decisions that can be somewhat independent of current energy prices.

Most of all, a strategic energy management plan should be realistic, and the best way to ensure that is to have a strong understanding of a facility ownership's return on investment tolerance. If ownership demands a one-year payback on energy management technologies, the plan will look much different than if a three-year payback is acceptable. Having this information in hand during the initial research phase can help resources better assist in plan development. Appropriate resources can include industry associations, like the Material Handling Industry of America, the local utility and suppliers of the full gamut of energy management technologies. "

We have selected Schneider Electric as a supplier for several motives. The first one is that this is a well know enterprise arround Europe, they work in every country, so one can get suppliers near to home. In Denmark one can find them at this adress: (Found at http://www.schneider-electric.dk/sites/denmark/da/generalt/kontakt/kontakt.page)

Schneider Electric Danmark A/S

Industriparken 32,

2750 Ballerup

Other reason is that one of the members of our group, Andrés Rubio Hernández, student of the Degree in Automatics, has worked with them as maintenance technician at Barcelona Airport, so he is familiarized whit their products.

And finally, as they say in their web page, Schneider Electric joins forces with its distributors to spread the message of energy efficiency. Its purpose is to achieve, with the participation of installers and specifiers, users and owners enjoy more efficient facilities, comfortable and safe. At the same time, they contribute significantly to environmental protection. Because of its proximity, the customer can trust the dealer and the product offers for maximum quality and energy performance. With its team of qualified technically and commercially is in the best position to listen and respond to questions about energy-efficient solutions.

According to their Guide of Energy-efficient solutions, found at: http://www.schneiderelectric.es/documents/local/soluciones/Guia-soluciones-eficiencia-energetica-2a-edicion.pdf , there is all a spectrum of products adapted to our necessities.

The first point to take in mind is the energy dilemma. With the Kyoto Protocol, industrialized countries have agreed to reduce their collective emissions of greenhouse gases by 5.2% for the year 2012, according to the 1990 emissions level. Currently, electricity is the largest contributor to the emission of these gases. Up to 50% of CO2 emissions attributable to residential and commercial buildings are from electricity consumption.

And with the proliferation of household appliances, computers and entertainment systems and the increased use of other equipment such as air systems conditioning and ventilation, electricity consumption is growing in a manner disproportionate to the use of alternative energies.

With their products, we can obtain a save of 30%, thank to the combination of:
From +15 to 10% with devices and efficient facilities: Low consumption, building isolate...
From +5 to 15% Using optimized installation and devices: Turn off if not required, regular engines, heating ...
From +2 to 8% Improvement Program and monitoring permanent: Maintenance, measurement and correction.

3.7.5. Standard ISO

The regulations are driving Energy Efficiency all around the world.
The Kyoto Protocol was the beginning of the establishment of quantitative objectives and an agenda with regard to reducing CO2 emissions with clear commitments from governments.

Beyond Kyoto commitment (until 2012), many countries have set a further time and objectives according with the recommendations of the Intergovernmental Panel on Climate Change (GIEEC) defined in the Convention UN Framework on Climate Change (UNFCCC) to stabilize CO2 levels at 450 ppm (to halve by 2050 the CO2 level of 1990).

The European Union is a good example and in March 2007 has sought at least 20% by 2020 (known as the 3 x 20: reduction of 20% CO2, 20% improvement in the level of Energy Efficiency and obtaining the 20% renewable energy).

This commitment could be extended to 30% in 2020 in case of reaching a post-Kyoto international agreement.

Some European countries are planning to commit up to 50% by 2050. It is shown that the context and policies Energy Efficiency will be present for an extended period of time.

To achieve these goals will require real change.

The regulations affect all sectors and influence not only the facilities and new construction, but also in buildings exist in regard to environmental care, industry industry or infrastructure.

At the same time, with the beginning of standardization have emerged a large number of new standards or are already being implemented.

In buildings, impact of all energy uses:

-Lighting.

-Ventilation.

-Heating.

-Refrigeration and air conditioning.

For industrial and commercial enterprises, the various agencies standardization is creating standard energy management systems, consistent with the known quality standard **ISO 9001** and **ISO 14001** environmental care. They are also developing Energy Efficiency Services standards.

Figures in our building

Inside a small and residential building, using this kind of automatics it could be saved between the 10 and 40% of electricity. Only the heating is the 30 % of the total consumption of energy. Lighting and home appliances are the 40% of the total. In order to get this save, we must use:

- Lighting control: regulators, electronic timers, detectors of movement and presence, specific switches, twilight switches.
- Climatic control: programmers schedules.
- Engine Control: programmers schedule variable speed drives.

- Management systems: Control Systems blinds. Systems lighting control. Control Systems households.
- Value added services: Remote Control. Media Control. Alarm management.

Solutions to implement

Lighting control

Automatically manage lighting by detecting moving in home.

We have chosen the Unica motion detectors, which it light turns on automatically when it is needed.

They can be recessed or surface mount indoor installations. There is more information in the page 210 of the document “Guía de soluciones de Eficiencia Energetica“. In the next picture it can be seen the Unica motion detector.

Figure 3.7.2.- *Motion detector switch Unica.*
From the document “Guía de soluciones de Eficiencia Energetica.

Commodities Energy Efficiency: Lighting control based on the presence of people, timing and brightness threshold.
There are two modes:

- Manual: the load is controlled with a push.
- Automatic: the load is controlled by motion detection and a brightness threshold
  predefined umbral.

Solution diagram:

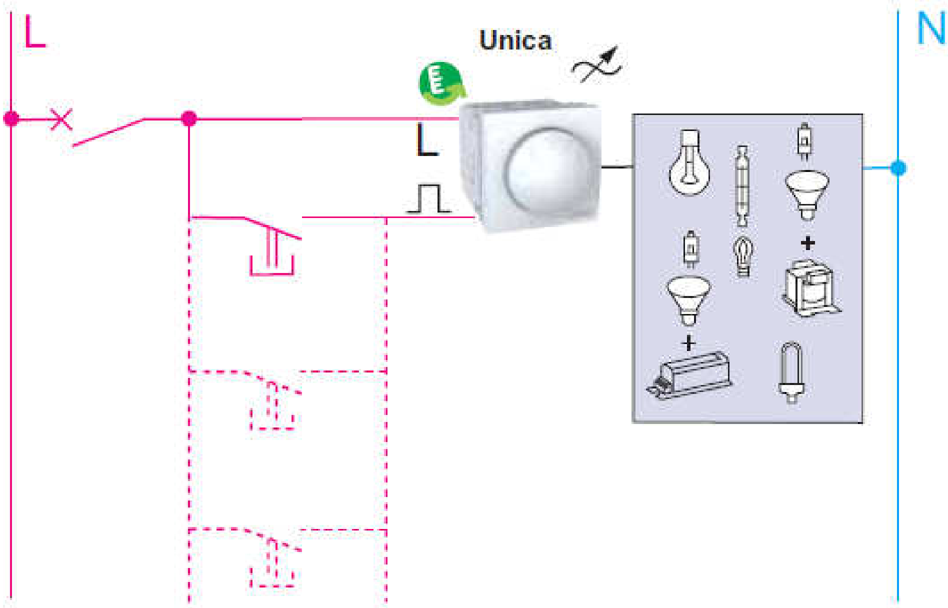


***Figure 3.7.3.-** Motion detector switch Unica solution diagram.*
From the document "Guía de soluciones de Eficiencia Energetica.

Ensure efficient lighting at the entrance to our block of flats.

The shared facilities of buildings (Halls, basements and garages ...) have use specific features on time and irregular. Also, are usually located in dark places that need light at all time of day or night. Lighting standing of these places is incompatible with the notion of saving energy.

We have chosen the electronic timer MINp, it effectively manage simple lighting temporary shared facilities of the buildings. The anticipated turning off reduced light intensity by 50% just before the final period, which can restart a new period of three minutes in a completely secure short of total darkness. If needed permanent lighting (service, maintenance ...), permanent lighting function ensures the continuous operation of the lights. There is more information in the page 203 of the attached document "Guía de soluciones de Eficiencia Energetica".

Figure 3.7.5.- *Electronic timer MINp.*
From the document "Guía de soluciones de Eficiencia Energetica.

Timer function MINP with integrated termination notice on the product:

-The shutdown timer can be set between 0.5 and 20 min.

-The timing of 1 hour set starts by pressing the control button for more than 2 s.

-The MINP can control lighting up to 3,600 W.

-Possibility to cancel the timer for a permanent lighting.

Diagram of the connection:

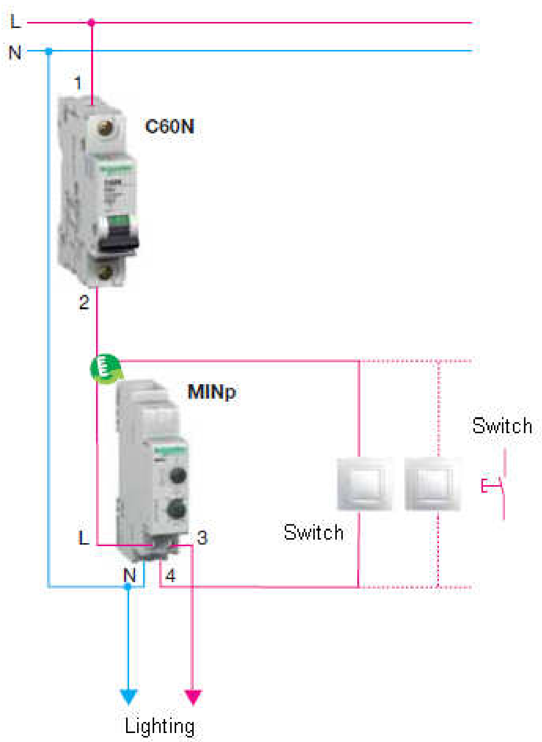


Figure 3.7.6.- *Electronic timer MINp solution diagram.*
From the document "Guía de soluciones de Eficiencia Energetica".

MINP timer switches need to connect in the installation phase. For higher power, use a CT contact and circuit breaker protection: its specifications depend on the installed power and type of load.

Climatic control

Temperature control via thermostatic valves

In our building we need to identify areas where heating is centralized. It must be possible to configure two temperatures and program modify its state time or using a interactive system. Saving energy by ensuring the comfort of the user, choosing the right temperature for each, or for each area of the house, at their election.

In homes or facilities with central heating, the consumption needs vary between properties of the same block, depending on the geographic and time of day. To reduce or increase 4 ° C heating in rooms or homes where the morning sun gives unlike afternoon, means less energy needs and therefore lower consumption of heating system.

We selected the Connect home automation control, regulation and programming of heating. Operates by radio frequency, so we avoid unnecessary wiring. Thermostatic valves should be installed Connect to radiator. They are powered by two AA batteries, 9 V. It has a programming software for the installation.

Figure 3.7.7.- *Connect Central RF.*
From the document "Guía de soluciones de Eficiencia Energetica".

Diagram of the connection:

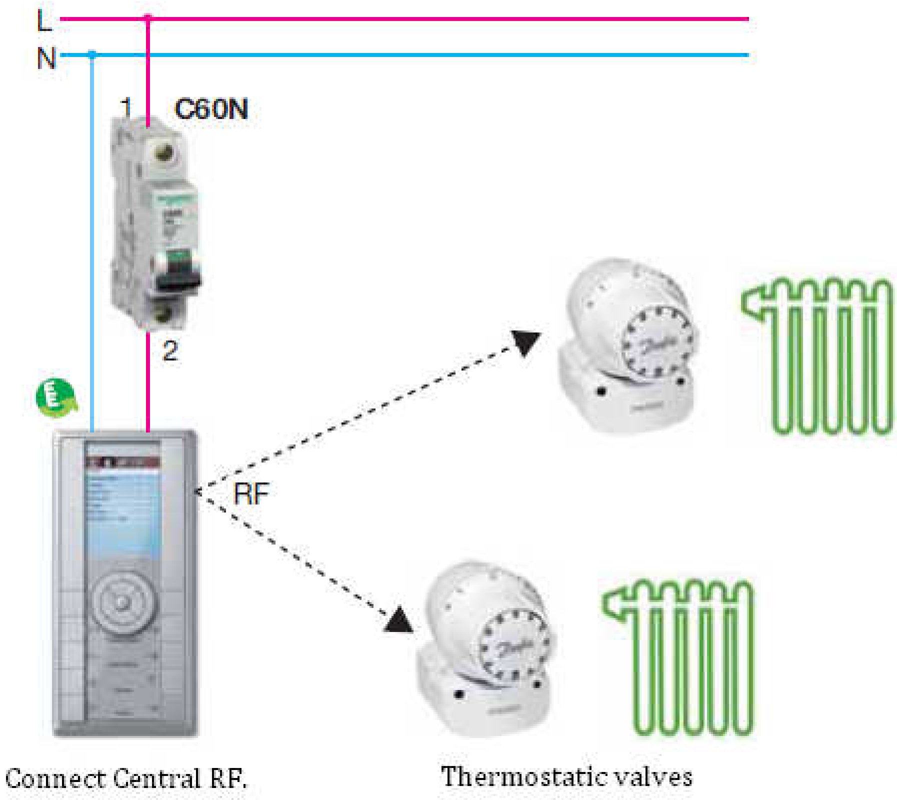


***Figure 3.7.8.-** Connect Central RF solution diagram.*
From the document "Guía de soluciones de Eficiencia Energetica".

Energy management

Identify sources of excessive consumption

Due to we need to identify sources of excessive consumption, it is necessary the installation of a consumption meter. We selected the kWh (kilowatts per hour) meter EN40, with which we can monitor electricity consumption and make the cost allocation and billing. Control their electricity consumption. Managing an electrical installation and optimize the energy consumption of our building.

***Figure** 3.7. 9. - EN40.*
From the document "Guía de soluciones de Eficiencia Energetica".

This range is particularly inexpensive and easy to install on all switchboards <10 kVA. The kWh meters EN40 are designed to measure active energy consumed by a single phase circuit. The range kWh meter EN40 complies with IEC 61557-12, IEC 62053-21 (Class 1), EN 50470-3 and MID (pending approval).Its small size allows for installation on compact switchboards. The lower link of the current input makes connecting the meter associated with the circuit breaker. You can use a pulse output to manage a group of meters remotely.

Diagram of the solution:

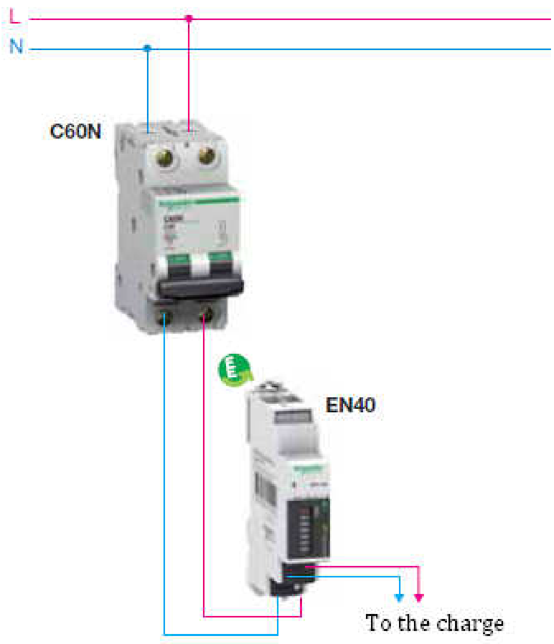


***Figure** 3.7.10. - EN40 solution diagram.*
From the document "Guía de soluciones de Eficiencia Energetica".

Security and continuity of service in front of atmospheric phenomena.

Due to inclement weather and other causes, it is necessary to protect equipment sensitive to possible surges caused by indirect lightning discharges and possible maneuvers network.

Figure 3.7.11.- *Lightning discharges.*
From the document "Guía de soluciones de Eficiencia Energetica".

We have selected a surge limiter Type 2 to protect electrical and electronic equipment with integrated automatic shutdown to ensure continuity of service when the limit reaches the end of his life.

Figure 3.7.12.- *Quick PF.*
From the document "Guía de soluciones de Eficiencia Energetica".

Quick PF 1 P + N Features :

Maximum download I max (8 / 20 s): 10 kA.

Maximum permissible voltage steady Uc: 275 V

Short circuit current Isc of automatic disconnection: 6 kA.

Engine Control

Garden watering control

In the drawings of our building you can see many green areas. Therefore we think that is a good idea to consider implementing an irrigation system, so that we can save water. We want to automate the watering of your home so that after a preset time switch on the irrigation system.

Figure 3.7.13.- *IHP garden watering control.*
From the document "Guía de soluciones de Eficiencia Energetica".

To automate the watering of housing the installation of a digital time switch IHP + 1C. Thus irrigation is activated at the present time and remains on during a time marked by the user. This timer is connected directly to the sprinklers, divided by landscaped areas according to vegetation. This timer can select the amount of water that we irrigate each zone. How adjusted weekly, one can distinguish the different seasons and the distinctions to water plants.

Diagram of the solution:

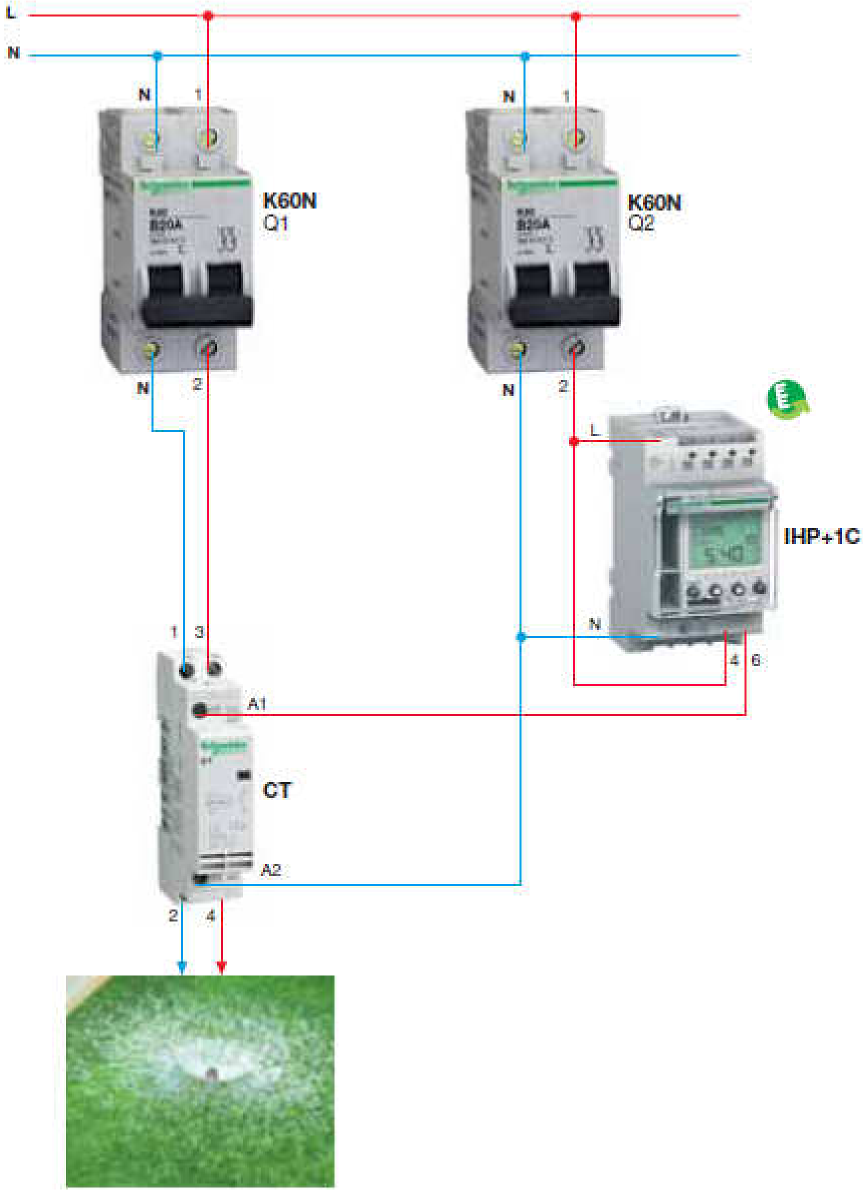


Figure 3.7.14.- *IHP garden watering control solution diagram. From the document "Guía de soluciones de Eficiencia Energetica".*

4. Field research:

In order to improve the research made, we decide to make some field research. It is a very good point to see how a low energy house is in practice. That is the reason why we visited ecological village near Aarhus.

4.1. Visiting an ecological village near Aarhus

We have visited an eco-village near Aarhus, called “Hjortshøj” where two hundred adults and children are living. This project of being in community and respecting the environment was imagined during The 90’s. Then, people of this village have built and designed their own houses and chose the best systems to isolate and equip the houses.

Their wishes were to reduce their heat consumption and their CO_2 emission. They decided to build their houses with a very good insulation to keep the heat and install some solar panels to heat the water.

The houses are largely insulated with “paper wool”, which is granulated recycled paper. Energy used for this type of insulation is much lower than the energy used for the traditional melting of glass and minerals.

The whole heating of homes and water is done either by burning wood chips or through solar heating. Wood chips are burned in their own central wood chip stove, which is coupled to a Stirling engine, which optimizes efficiency by also producing electricity.

Picture 4.4.1: *The first boiler was a granules Boiler (180kW)*

Picture 4.4.2: *When you open the door, you find the granules tank*

Picture 4.4.3: Later on, they installed a central wood chip stove (160kW):

Here you can see the wood chip tank. Each week, a truck comes and delivers wood chip. In winter, 100 meters square are delivered per week

Picture 4.4.4: *Wood chip*

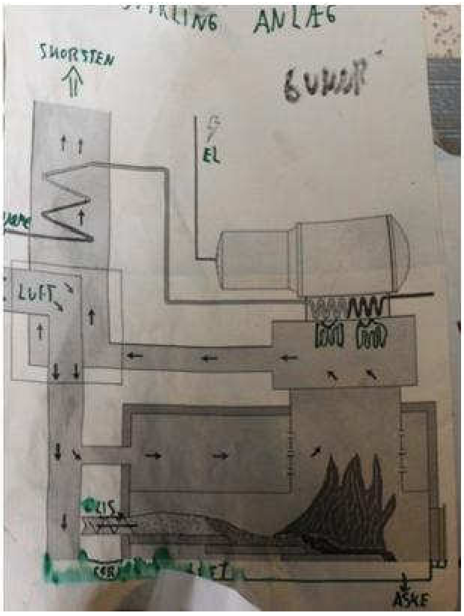
.

On the other side, a Stirling engine has been built so that electricity can be produced:

Picture 4.4.5: *Stirling engine*

Here you can see the wiring diagram of Stirling engine. The wood chips are burnt and the heat produced is used from the Stirling engine.

Picture 4.4.6: *Diagram*



All the houses and common houses are equipped by solar panels and they can use the panels during few months, from May until October for the hot water.

Picture 4.4.7: *Common house*

Picture 4.4.8: *Roof of the house*

The village is devised in different districts and all the districts have a common house which can be used to organize dinners all together or invite guests. And each house is very well-equipped.

Picture 4.4.9: *Common kitchen*

Each common house has also a washing machine room. The water used for washing comes from the rain.

Picture 4.4.10: *Common washing machine*

Description of the current activities :

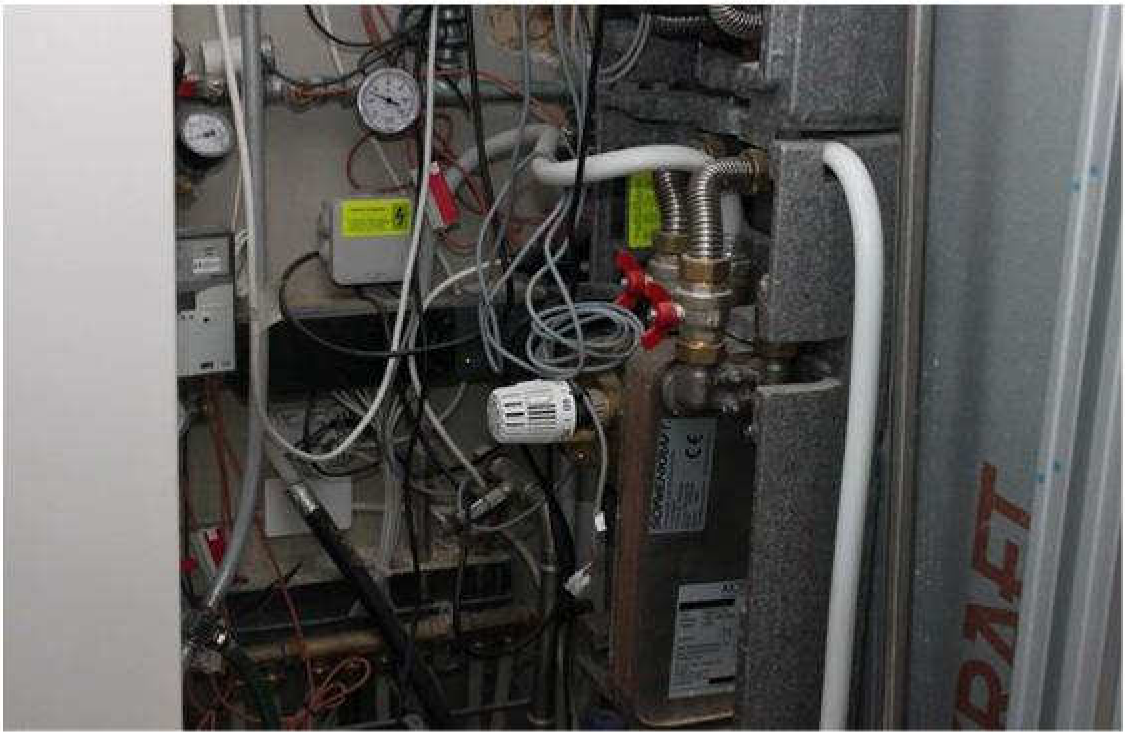
⇨ The people of the village use a car for many families which can contribute to the respect of the environment and to save money.

⇨ The village can use 1, 5 hectares to make grow vegetables and fruits.

⇨ They have built an underground tank at 3 meters deep. It's used to collect grey water and black water. During the summer period, the water evaporates and just the organic wastes leave. It's used to make the trees grow, which are used for the heating.

Low energy houses are so well insulated that there is no air transfer between the inside and the outside. So they need a double flow ventilation system to change the air every two hours.

Picture 4.4.11: *double flow ventilation system*



Picture 4.4.12: *Ventilation*

The ventilation is also used as vacuum-cleaner. You just have to plug a pipe into the socket you can see on the next picture in order to clean the ground.

5. Framework

After carrying out some eye-opening research, a design framework was made. The first two points in this framework are "What?" and "How?" This is to make it absolutely clear of exactly what the aim of the product is and how it will be achieved. This is then broken down into more specific points.

In order to reach the class 1 danish standard We need to fit to some special rules and regulation for building construction. A low energy performance framework for residential buildings, student halls of residence/dormitories, hotels etc., i.e. a building whose total demand for energy supply for heating, ventilation, cooling and domestic hot water per m2 of heated floor area does not exceed 35 kWh/m2/year plus 1100 kWh/year divided by the heated floor area may be classified as a class 1 low energy building.

Buildings must be constructed such that, under their intended operational conditions, a healthy, safe and comfortable indoor climate can be maintained in rooms occupied by any number of people for an extended period. Buildings must be constructed such that, under their intended operational conditions and at levels appropriate for the human activities to be carried out in them, comfortable, healthy temperatures can be maintained in the rooms occupied by any number of people for an extended period. The recommended temperature for buildings is about 19°C in every rooms, about 22°C for bathrooms and around 16°C for stairs.

For the building insulation there is a guideline for standard U-value:
For walls and floor it should be less than 0,2 W/m².K
For roof, it should be around 0,15 W/m².K
For windows it should be around 1,5 W/m².K
But off course for reach the class one, those numbers are only guideline, it is the entire system which reduce the energy consumptions.

Buildings must be ventilated. Ventilation systems must be designed, built, operated and maintained such that they achieve no less than the intended performance while they are in use. Fresh air must be provided through openings direct to the outside or by ventilation installations with forced air supply. Transfer of air from one room to another may not be from a more to a less air-polluted room. Ventilation installations and ventilation openings direct to the outside must be designed and installed such that they do not transfer substances to the ventilated rooms, including micro-organisms, which render the indoor climate unhealthy.

Central heating boilers, small-scale CHP plants (combined heat and power), generator systems, biofuel systems, wood-burning stoves, fireplaces and other heating appliances must be built and installed to prevent the danger of fire, explosion, poisoning and health nuisance. Materials with the requisite resistance to flue gases, fire, heat and corrosion must be used. Heating appliances must be designed and installed such that they can be cleaned without difficulty.

We are also interested about the guidelines and what kinds of guidelines we could do apply for our building. In fact after studied the heating system, the insulation and the other different parts so that our building is a “low energy house”, we would like the residents can save energy every days. Simple rules but which can allow to save money can make a difference between before and now. The different kinds are electricity, wastes, water and they are very important for the Earth.

A°) Electricity

In first, there are some rules we can do for save electricity :

- They can avoid too warm machine or just when it is necessary, when you wash at 40°C you consume 25% less than a cycle at 60° C.
- It is better to use induction cookers, it is more economic than a vitro-ceramic.
- Use the residual heat of the cookers for the end of the cooking (inertia).
- Unfroze the fridge every 6 month, you can consume third as less electricity.
- Use electric devices when the electricity is cheap (washing-machine, dryer, oven)
- Install an economical toilet flush.
- Don’t let the electrical devices in stand-by.
- Switch off the lights when it is not necessary.
- Buy low consumption lamps.
- Buy grade A household devices.
- Favour the daylight.
- Clean regularly the lamps for optimize them efficiency.
- Cover the pans while cooking, you can economize 30% of energy.

- Put the fridge in ventilated rooms like that there are no overheating.

B°) Water

We can save also water by simple rules like :

- Do not let the water on while washing your hands.
- Use flow limiters for the shower and the taps, you can reduce your consumption of water by 50% by year.
- Prefer showers to baths.
- Do not let the water flowing while washing the disches, when you wash your hands or brush your teeth.

C°) Electricity and water

And you can save electricity and water together, when we fill up the entire washing machine.

D°) Wastes

It is very important to sort out the wastes (papers, glasses, plastic...)

E°) Heating

About the heating system, we can do some rules for save energy like :

- Switch the heating off while airing
- Do not air too long
- Program the heating system in function of the life rhythm (1°C increases by 7% of the energy consumption.)

D°) Ecology

- Finally we can use non polluting detergents.

Through those rules and regulation, a good framework appear. It give a better definitions of aims and also some very interesting values. With this, a very good guide line is make. And it specify what and how can we make this project work. We will calculate approximately most of values by our selves and use ASCOT program given by cenergia company for the total calculation and such.

6. Technology solution selection and adapting for building

The research made gave us a lot of knowledge's for our project. After we did research we have to apply it to our project. We collect enough information for being able to design our own systems for low energy building. Our final solution should incorporate the four main aspects of the project which are building insulation, ventilation system, heating system and solar panels photovoltaic. It is a solution applied to our buildings, with calculation and different steps in order to reach the class 1 Danish standard and give a proper solution to the main aims of the project.

6.1. Building insulation applied to the project

The insulation of the building is very important for decrease the energy consumption of the heating system and make a pleasant atmosphere in the building. The main part of the building which need to be insulated are the exterior walls, the roof, the floor and the windows (and doors with an access to the outside of the building).

After the research made, it is clear that a lot of solutions are possible for this building. But we can imagine a "main" solution in order to use it as a guide line.

6.1.1. Wall Insulation:

For the exterior walls, it seems that using an outdoor insulation is a good process to keep the building in a constant temperature. For and outdoor insulation, wool fiber is good insulator and it is very easy to install and cheep. The wideness of wool fiber should be around 150 mm. In order to improve the insulation it is also possible to use wood fiber panels as indoor insulation. Simple wood panel (about 100 mm wide) increase again the insulation but it also in order to use the other properties. Especially the Hygroscopic insulation which can store moisture, purify the air in the house and regulate humidity.

For glass wool the coefficient of thermal conductivity is : 0.047 W/m.K

For wood fiber the coefficient of thermal conductivity is : 0.038 W/m.K

With this type of insulation the U-value of the walls will be :

$$U=1/(0.13 + 0.04 +(0,15 / 0.047) + (0.1 / 0.038)) = 0,16 \text{ W/m}^2\text{.K}$$

6.1.2. Roof insulation:

For the roof it is possible to use wool fiber (about 150 mm) for a first indoor insulation layer and put a second layer of thin Insulation (about 100mm). It is a good point to have a reflective material in roofs, because the warmer air tend to go up. But with a reflective layer it can contribute to keep the inside air to a constant heat and avoid any heat flux in the building.

For thin Insulation the coefficient of thermal conductivity is : 0,045 W/m.K

With this type of insulation the U-value of roof will be :

$$U=1/(0.1 + 0.04 + (0.15/0.047) + (0.1/0.045)) = 0{,}18\ W/m^2.K$$

6.1.3. Floor Insulation:

For the floor insulation the most used material is Styrofoam insulation. It have enough thermal insulation properties it is really cheap and very easy to install. A layer about 250 mm is enough for create a good floor insulation.

For Styrofoam insulation the coefficient of thermal conductivity is : 0,047 W/m.K

With this type of insulation the U-value of floor will be :

$$U = 1 / (0.17 + 0.04 + (0{,}25 / 0{,}047)) = 0{,}18\ W/m^2.K$$

For the windows the best and most common way is to use double glazed windows. The Low emissivity windows can be used for have very good properties. It enable the solar radiation to warm up the building. But it can be used with some special layers for acting as filters for light radiation transmission. But by putting layer with high efficiency filters generate thermal stress on the glass which is not a good point because it create weakness in the glass. As our building is in the center of Copenhagen the phonic insulation properties of those windows can be very appreciate. The standard U value for double glazing low-E is 1.8 $W/m^2.K$, but if we use a double glazing low-E treated with Argon, it can reach a U value of 1.5 $W/m^2.K$.

6.1.4. Installation process

Most of those insulating materials can be found into panel form. So for install them, it need to be put into an aluminum (or other metal) rail framework screwed in the walls. It is not a very complicated or expensive process . As you can see on this picture the space between each rails and wall depend of the size of piece of insulating material used.

Figure 6.1.1. *Installation of wall insulation.*
http://www.placo.fr

Before to install insulating panels, be sure that it is:

-correctly sized to fit snugly at the sides and ends
-installed to completely fill the cavity
-cut to fit properly -- there should be no gaps, nor should the insulation be doubled-over or compressed

-non-standard-width cavities shall be filled by insulation panels cut approximately one inch (1") wider than the space to be filled
-cut to butt-fit around wiring and plumbing, or be split so that one layer can fit behind the wiring or plumbing and one layer fit in front

Obstructions from pipes conducts or else:

-insulation shall be cut to fit around wiring and plumbing without compression
-insulation shall be placed between the sheathing and the rear of electrical boxes
-insulation shall be cut to fit around junction boxes
-in cold climates water pipes shall have at least two thirds of the insulation between the water pipe and the outside. If the pipe is near the outside, as much insulation as possible shall be placed behind the pipe and no insulation shall be placed between the pipe and the inside.

How to install insulation panels:

Insulation is very easy to work with, it doesn't require strength or tremendous skill. The rolls or panels should fit snugly between the studs, and the only trimming you'll have to do is around windows, doorframes, electrical outlets and plumbing. It cuts easily with a utility knife and is extremely lightweight.

Against every walls should have a metallic rail frame in order to insert the panels inside this frame (between the rails). It is a very simple process and the only precision required is for calculate the space between each rail. Here is a detailed picture of the rails used for install building insulation:

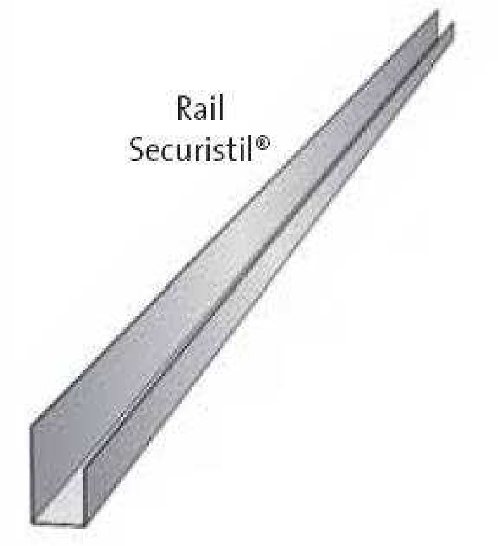


Figure 6.1.2 *Example of rail used for fix insulating panels.*
http://www.e-toiture.com

It is very simple rails and it is very easy to make a frame with it. It is basically the same process for walls and roof thermal insulation.

But the panels have to fit exactly (more or less) to the frame, in order to avoid the creation of thermal bridges. Thermal bridges are basically a way through the insulation where the heat can move (from inside to outside or opposite) by any heat transmission mode existing.

In real situation there is always thermal bridges which can come from a thin space between the panel and the rail or just a screw which drive the heat from to wall to the inside for example. But with a good insulation, thermal bridges only represent very few losses compare to the entire house but it still an issue and the installation of insulating materials must be done by professional using proper tools and materials.

Sealing for roof:

This building have flat roof and it represent an issue because of water infiltration. When it rain, the water stay on the roof and goes through the concrete and insulating materials. This represent two main problems:

-First, the water infiltration in the building increase the air humidity, the walls became wet and this is a source of sickness and moisture development.

-Second, when insulating materials such as wool and wood fiber became wet, they loose they insulating properties and after they need to be change because of the development of mold in it.

It is the reason why roofs (and specially flat roof) needs a very good waterproof insulation. But this is not enough, flat roofs also needs a way to evacuate this still water , so they should not be flat but with just a little inclination and whatever a hole or else to evacuate this water.

Figure 6.1.3. *Installation of roof sealing.*
http://www.barbot-guesdon.fr

As you can see on those pictures it consist of a simple and very thin layer to put on the outside roof. In those days the most common material used for sealing is PVC layers. For the installation process a blowtorch or a burner is needed for have an efficient sealing and avoid any water infiltration.

Floor insulation, installation process:

Installation of floor insulation is a very straightforward process. If the house is a new construction, it is easily done before subfloor goes down. It is an easy process similar to wall installation process but even easier as the structure is on the floor. And by using styrofoam, it became easier, because it is a very inexpensive material and it is very easy to cut for fit to the shape wanted.

Conclusion:

In order to summarized, the insulation of this building is an important issue for reduce energy consumption. To be considerate this building as a “Low energy house” it is very important to have an efficient insulation. As the energy consumption of the heating system represent the biggest part of the building, it enable us to save a lot of energy. Our solution for this building use common and quite cheap materials but the efficiency is very good and enable this building to reach the class 1and be considerate as a low energy building.

6.2. Ventilation system for low energy house

6.2.1. Figures in our building

The first step is to find the area of each apartment, divided by type of room. With these data we can find the flow of air must be supplied to each apartment. In the following pictures you can see the drawings of an apartment two floors, and the squared meters of each room. Were not taken in mind the common areas or gardens. The areas are known to have an area of 302,1 m^2 , and the gardens should not be aired because they are outdoors.

Drawings of one flat (B4):

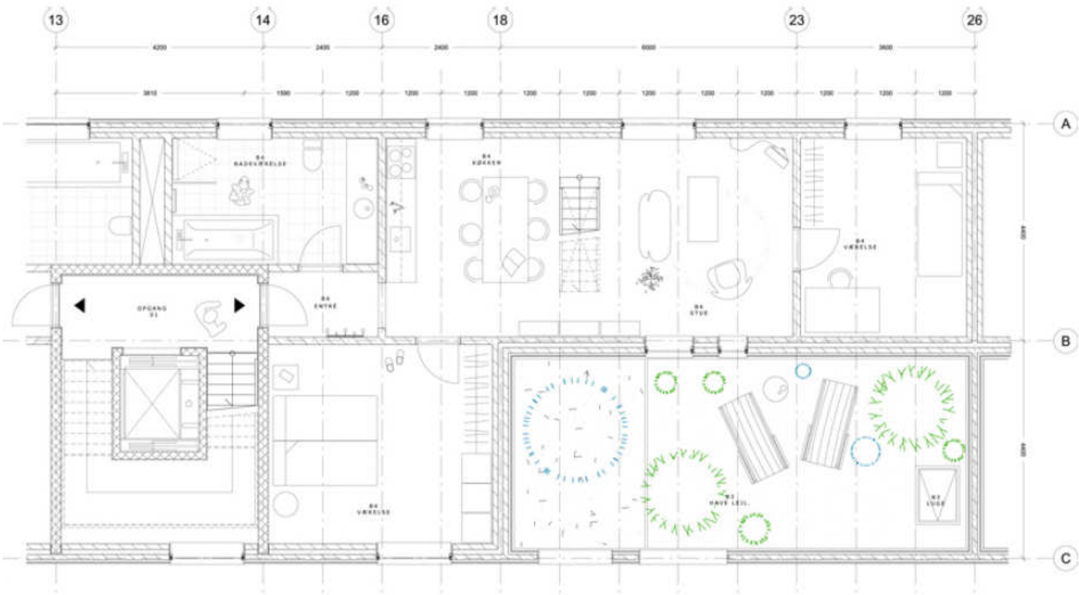


Figure 6.2.1.- *Drawing of the flat B4, first floor.*
"FRA GÅRDEN TIL GADEN"

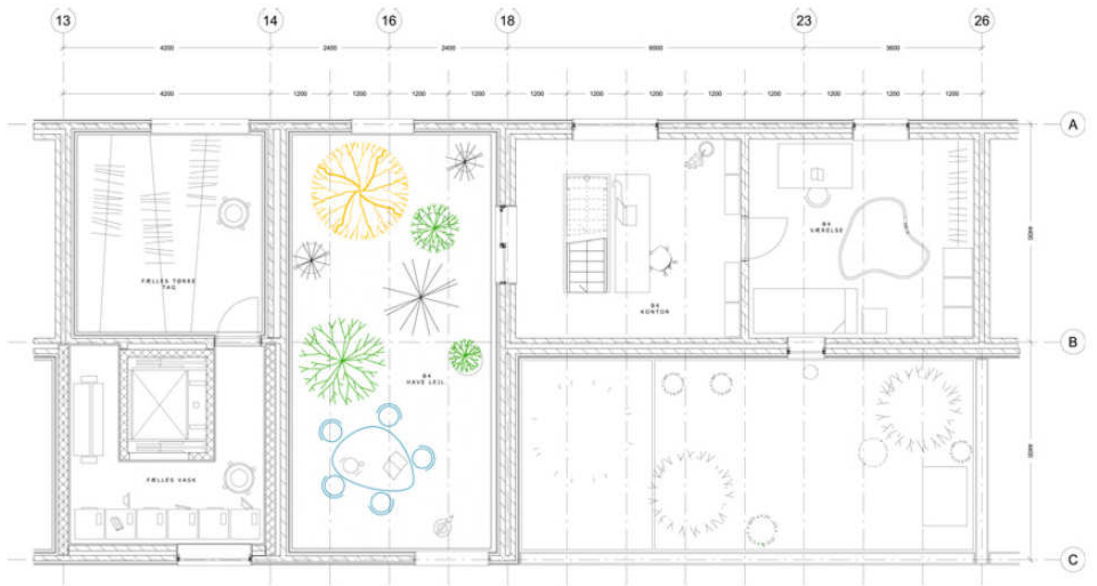


Figure 6.2.2.- *Drawing of the flat B4, second floor.*
[*"FRA GÅRDEN TIL GADEN"*]

Drawings of one flat, with the surface in squared meters, in red.

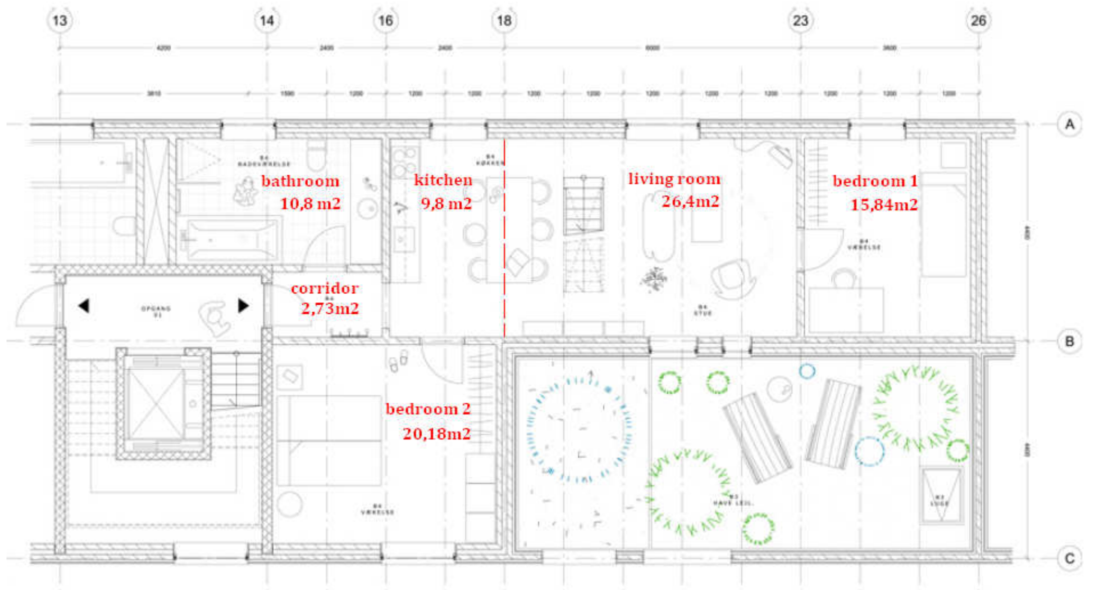


Figure 6.2.3.- *Drawing of the flat B4, first floor, with surface.*
[*"FRA GÅRDEN TIL GADEN"*]

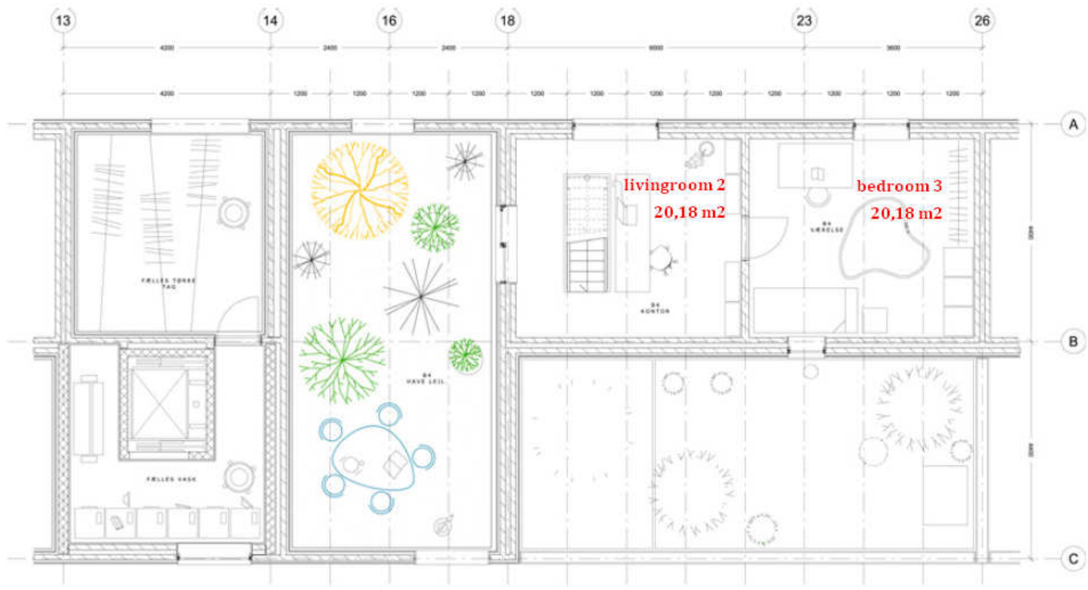


Figure 6.2.4.- *Drawing of the flat B4, second floor, with surface.*
"FRA GÅRDEN TIL GADEN"

The total area to be ventilated at this flat is 128 m2. including the kitchen occupies 7.6%, 8.4% the bathroom, and other areas, such as livingroom, bedroom and corridor, the remaining 84%.

Although each flat has a different distribution, to simplify the calculations, we are going to extrapolate the results to the rest of the building.

The sum of all habitable areas of the building is 4167.4 m2. Extrapolating the data above, we get 3500.6 m2 of livingroom, 350 m2 of bathroom, and 316.7 m2 of kitchen. In addition to 302.1 m2 of common areas.

The following table shows the relationship between surfaces of different types of rooms of the building, with the amount of flow required to satisfy the requirements in denmark. At the end of the table we obtain the total flow required for the entire building. With this information we will have to find the right solution.

Relationship table between surfaces of different types of rooms of the building:

Areas of the building	surface (m2)	Residences Minimum Air Flow Rates (l/s*m2)	total (l/s)	m3/s
SUPPLY				
livingroom	3500,6	0,35	1225,2	1,23
common areas	302,1	0,35	105,7	0,11
together			1330,9	1,3
EXHAUST				
bathroom	350	15,00	5250,0	5,25
kitchen	316,7	20,00	6334,0	6,33
together	4469,4		11584,0	11,58

Figure 6.2.5.- Relationship table between surfaces of different types of rooms of the building.

As you can see, there is a difference between the supply air and exhaust. This is because the exhaust requirements are much greater than the supply. On our project we will consider only the values of Supply to make the calculations, and work under the assumption that the exhaust air will be used only when areas like the kitchen or bath are in use.

Solutions to implement

We have selected the model SHR 3205R by FANTECH, INC. (FANTECH), whose specifications are:

Electrical Requirements: Volts: 120 Amps: 2.5

Exhaust Air Transfer Ratio: 0.03 @100 Pa/0.4 in. wg --- @ 50 Pa / 0.2 in. wg

Low Temp. Vent Reduction Factor: 11.8% Supply 13.4% Exhaust. Low Temp.

Imbalance Factor: 1.00.

Relationship table between pressure and the amount of air exhausted and supplied:

VENTILATION PERFORMANCE							
EXT. STATIC PRESSURE		NET SUPPLY AIR FLOW		GROSS AIR FLOW			
				SUPPLY		EXHAUST	
Pa	in wg	L/s	cfm	L/s	cfm	L/s	cfm
75	0.3	140	297	144	306	153	326
100	0.4	126	267	129	275	141	299
125	0.5	114	243	117	250	125	266
150	0.6	104	222	108	229	115	244
175	0.7	92	195	94	201	103	219
200	0.8	80	171	83	176	89	190
225	0.9	69	147	71	151	79	169
250	1.0	58	124	60	128	71	150
275	1.1	47	101	49	103	55	117
300	1.2	38	81	39	84	45	96
325	1.3	30	63	30	65	31	66
350	1.4	21	44	21	46	18	39

Figure 6.2.6.- *Relationship table between pressure and the amount of air exhausted and supplied.*
1993 ASHRAE Handbook Fundamentals.

For a pressure of 75 Pa, provides a supply of 144 l / s. Since we need to 1300 l/s for the whole building, we installed 10 units scattered throughout the building.

In the next graph you can see the relationship between pressure and the amount of air. The upper line represents the exhaust air, and the lower the supply air.

Relationship graph between pressure and the amount of air exhausted and supplied:

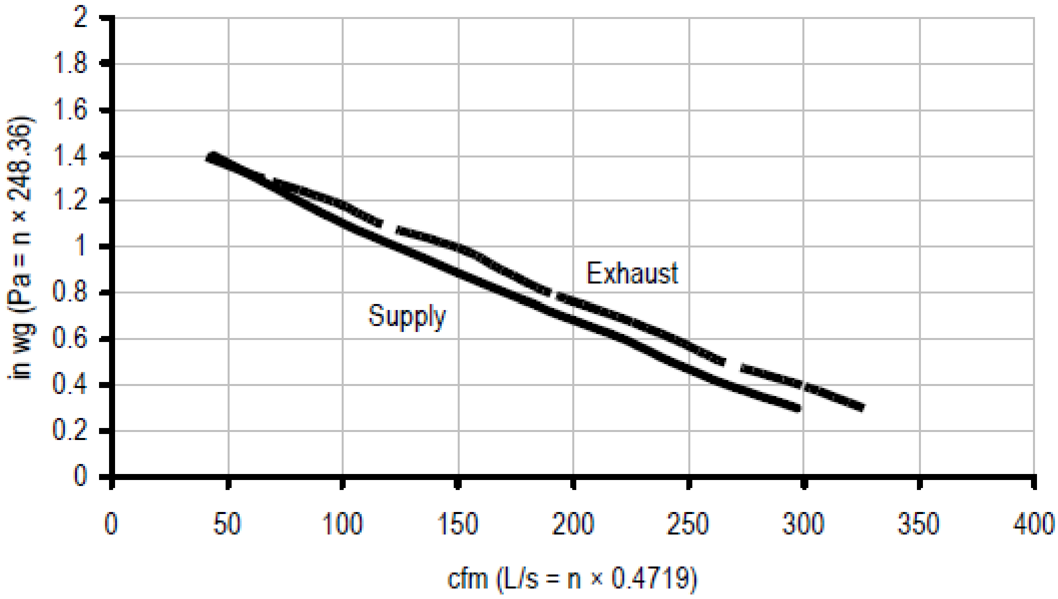


***Figure 6.2.7.**- Relationship graph between pressure and the amount of air exhausted and supplied.*
1993 ASHRAE Handbook Fundamentals

As noted in the table below, applying this improvement we can get 66% sensible recovery efficiency. Taking into mind that each of the ten units cost around 400 DKK, adding the costs of installation, we can say that the total cost will be approximately 10,000 DKK.

ENERGY PERFORMANCE

	SUPPLY TEMPERATURE °C	°F	NET AIR FLOW L/S	CFM	POWER CONSUMED WATTS	SENSIBLE RECOVERY EFFICIENCY	APPARENT SENSIBLE EFFECTIVENESS	LATENT RECOVERY/MOISTURE TRANSFER
HEATING	0	+32	56	118	136	66	77	0.02
	0	+32	76	162	182	66	76	0.02
	0	+32	116	248	272	64	74	0.03
	-25	-13	58	123	168	67	79	0.05

***Figure 6.2.8.**- Energy performance table.*
1993 ASHRAE Handbook Fundamentals

Conclusions:

Ventilation system is necessary to prevent the Sick Building Syndrome (SBS), toxic pollution from chemical substances, dust, accumulation of microbes, bacteria and viruses, and reduce the exposure to allergens.

Denmark rules, New Building regulations in 2008 , dictate the amount of air that must be supplied and exhausted. In every room as well as for the whole residence the supply of outdoor air shall be minimum 0,35 l/s m2; air shall be exhausted from kitchen (20l/s), bathroom (15 l/s), toilet (15 l/s) and similar rooms.

Ventilation investment in the system is very low and very high savings, up to 66%, so the investment is recovered quickly.

6.3. Hot water heating system for "a low energy house"

Building hot water system consists of solar heating system and from extra boiler (district heating) in case if there will not be enough energy from the sun.

We calculate that in this building approximately 90 people will live and on average one person consumes 40 liters of hot water per day. So it is 40 x 90 = 3600 l per day.

1 m^2 solar collector can prepare 50 l per day.

Area of solar panel = 3600 / 50 = 72 m2

Size of water tank should be a little bit larger than the amount of water needed per one day and it is $\geq 3.6\ m^3 = 4\ m^3$

Complex structure of the roof does not allow to make easy solar collector system. The main problem is that roof is separated in many small roofs. (Figure 6.3.1)

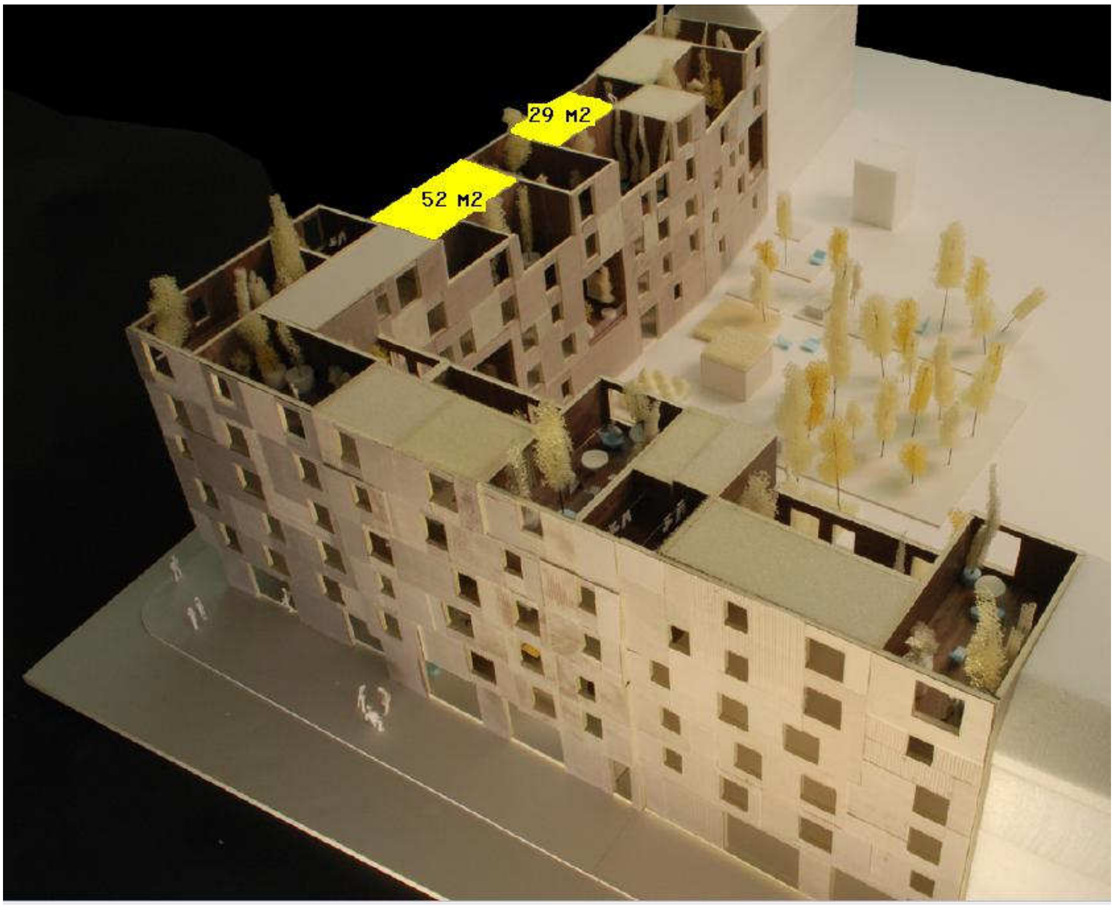


Figure 6.3.1. *Solar collector location on the roof.*

"FRA GÅRDEN TIL GADEN" 91209 "Ålandsgade-karreen-idekonkurrence"

Yellow colour (Figure 6.3.1.) marks the place where it is planed to install a solar collector.

The next complication was that the roof is flat. Therefore a decision was taken to make an additional structure for the solar collector.

Reduction factor due to the solar collector orientation and inclination

Table 6.3.1

	South	South +- 22.5°	South +- 45°	South +- 77.5°	South +- 90°
15 °	0.91	0.93	0.89	0.86	0.82
30 °	0.96	0.95	0.92	0.88	0.82
45 °	1	0.98	0.95	0.9	0.81
60 °	1.01	0.99	0.96	0.89	0.79
75 °	0.98	0.96	0.93	0.86	0.75
90 °	0.91	0.89	0.85	0.78	0.69

http://www.batec.dk/_da-DK/Content/Data/PDF-dokumenter/Datablade/Reduktionsfaktor%20som%20flge%20af%20solfangerens%20orientering%20og%20hldning.pdf

As you can see in table the most effective inclination is 60° and coefficient is 0.99 if orientation is South +-22.5°. Our solution is to make extra construction for solar collectors, because of flat roof and limited area. But to make construction with inclination 60° is too complicated and expensive. That way we chose to make construction in 15° degree angle and lose a little bit of the sun energy with lower reduction factor (Table 6.3.1), but still use all area of both roofs of 52 and 29 square metres (Figure 6.3.2).

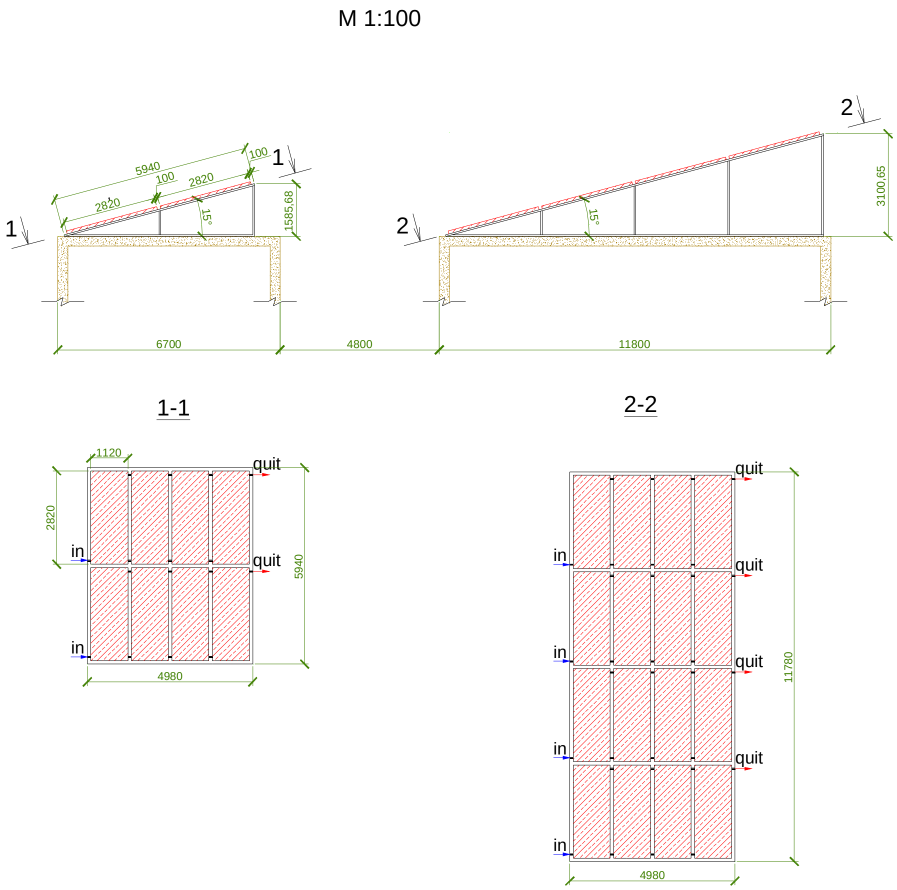


Figure 6.3.2. *Solar collector construction*

We chose to use Batec BA 30 solar collectors. (Figure 6.3.3) (Full description see in the Appendix 3).

Figure 6.3.3. *Batec BA 30 solar collectors*
http://www.batec.dk/_da-DK/Content/Data/PDF-dokumenter/Vejledninger/Montering%20af%20fittings%20p%C3%A5%20solfangere.pdf

Size of one collector is 1120x2820mm, gross area 3.16 m^2, aperture area 3.0 m^2.

Collectors are connected in parallel rows, each row consist of 4 collectors. Total number - twenty-four "Batec BA30" solar collectors. (Figure 6.3.3. and 6.3.4.)

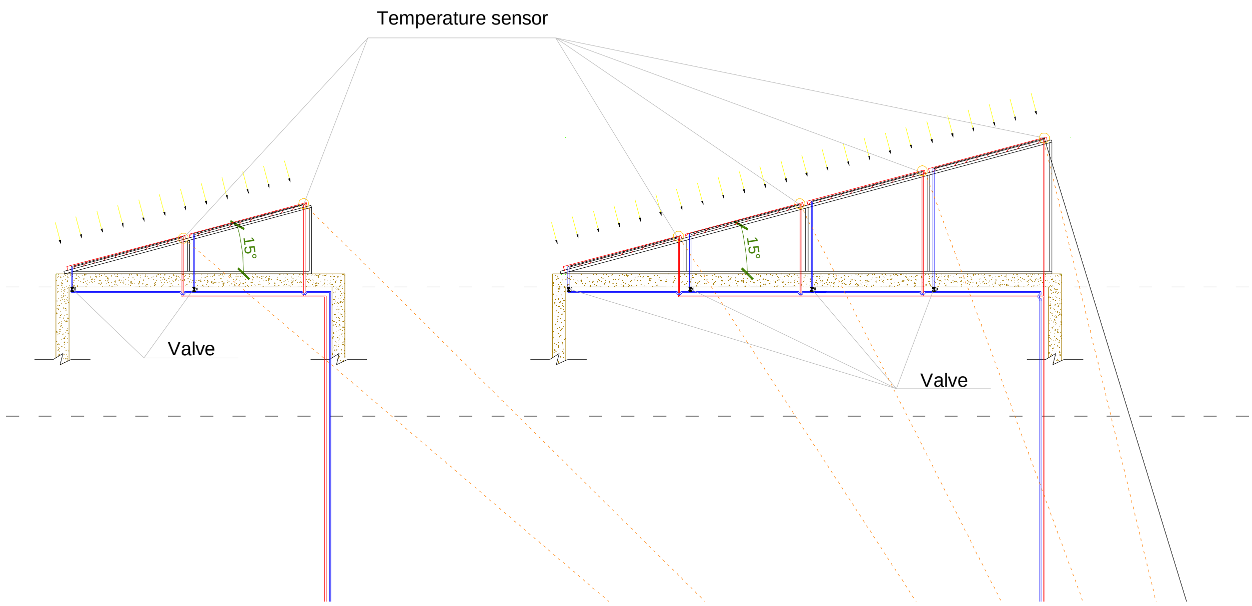


Figure 6.3.4. *Drawing of solar collector locations*

Each parallel row with solar collector has a temperature sensor, together 6 sensors. It is needed to calibrate system with valves for the same flow in every row of solar collector. Also it is needed for automatic control system to calculate if the medium temperature between solar collectors is higher than in water tank and automatic system starts or stops pump or to alarm if the temperature between solar collector rows is different.

We have designed two types of system:

- with drain-back system (see appendix 2)
- without drain-back system (see appendix 2)

There are some advantages and disadvantages for each system.

6.3.1. Hot water heating with drain-back system

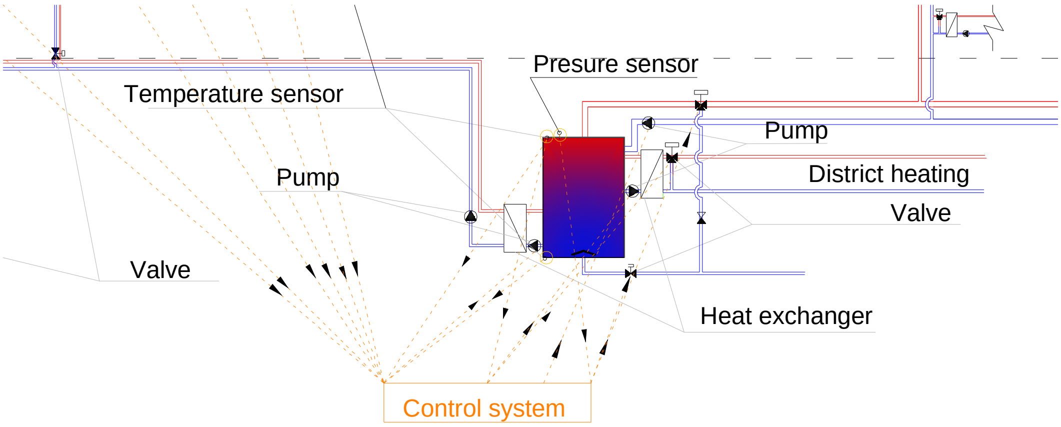


Figure 6.3.5. *Hot water heating with drain-back system.*

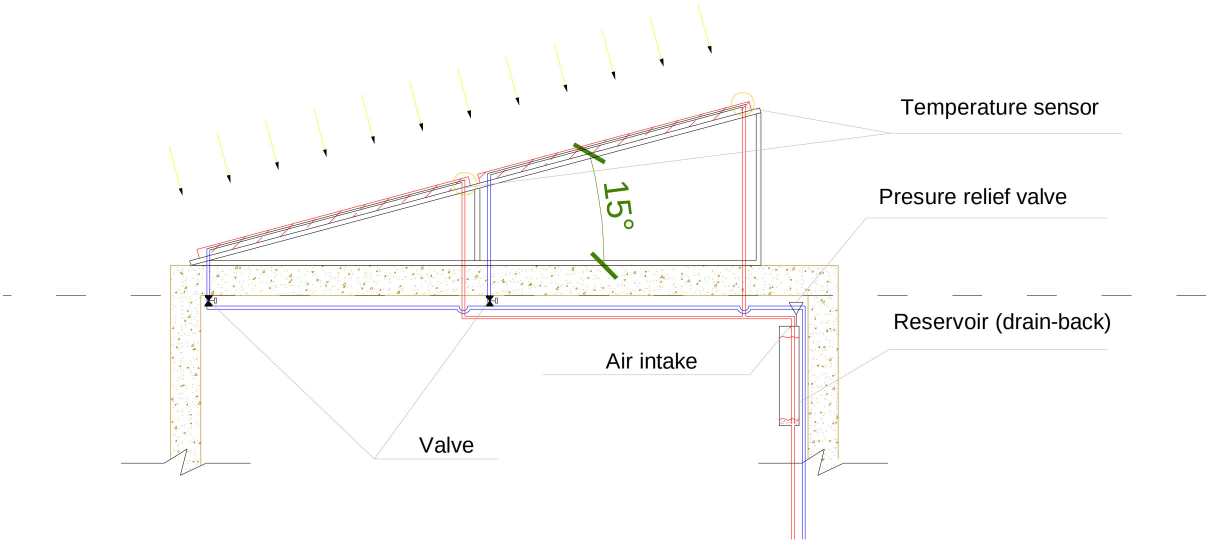


Figure 6.3.6. *Hot water heating with drain-back system.*

If this system is chosen, the pump position place is really important. The pump should be placed on vertical return pipe as you can see on Figure 6.3.5, because this system has the possibility to get air in the system from drain-back reservoir. If pump is on vertical pipe the air which goes in pump, goes out because of gravity and system work is uninterrupted.

Drain back reservoir should collect all water from solar collectors and pipe above reservoir. We calculate that the size of both reservoirs should be:

1) >(8 x 2.26 >18.08) = 30 Liters
2) >(16 x 2.26 >36.16) = 60 Liters

It is really important to have air intake in top of the drain back reservoir for filling the collectors with air in case when the system is stopped. (Figure 6.3.6). The pipe is located inside the reservoir 5 - 10 cm above the bottom. The air intake can be a hole in the inner tube.

This height from bottom without tube is necessary to avoid the possibility that air enters in the circulation loop.

The advantages of the drain-back system are:

- 100% safe against overheating
- Protection against freezing (no need to use glycol, water can be used)

The disadvantages of the drain-back system are:

- Drain –back system requires at least 50 and 100 litter reservoirs in the 4th floor area.
- A more powerful pump is required to pump up water from the reservoir level up to the solar collector (approximately 3-4m) when the system has been stopped and has to be restarted again.

6.3.2. Hot water heating system with the expansion tank and pressure valve

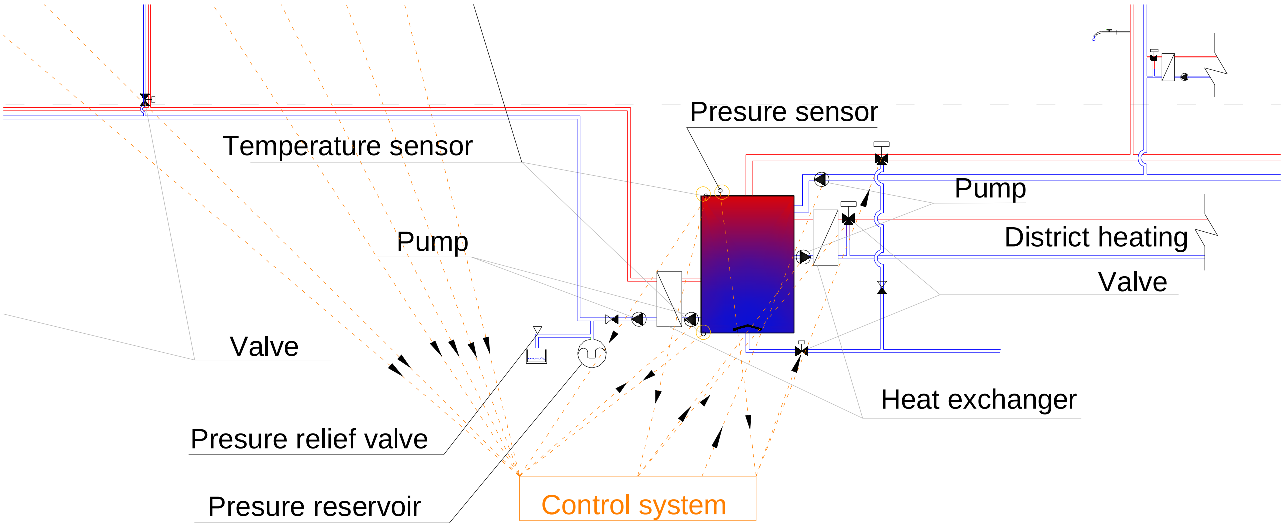


Figure 6.3.7. *Hot water heating system with the expansion tank and pressure valve.*

This main difference is that this system does not provide air presence in the system. There are bleed valves installed in the parallel rows of solar collector. In case the liquid of the solar collectors begins to boil resulting in additional pressure, the pressure reservoir tank starts to load with water. A non-return valve is installed between the pressure reservoir and heat exchanger. In cases when the pressure is too high and the pressure reservoir tank cannot pick up all the pressure, an overpressure valve is triggered and excess fluid is released into the bulk tank. If such an event occurs the system must restart and bleed off air.

The advantages of the system without drain-back:

- Less powerful pump
- Take less space in living area (no reservoir in 4^{th} flour)

The disadvantages of the system without drain-back:

- In extra case when the sun is very active and nobody will use hot water energy it is possible that the system starts boiling and the pressure reservoir cannot take all pressure and the pressure valve works and discharges some liquid out of the system After that case it is necessary to refill liquid in the system and restart it.

6.3.3. Extra systems for hot water heating

In case when there is not sufficient energy from the sun, the system will use district heating. It will be like an extra boiler and trough heat exchanger it will give extra heat energy to system.

We have designed a system with mixing valve that mixes cold water with the solar-heated water before it enters the tap. It is made so to exclude any possibilities that the water burst out as steam exiting the tap with high probability to scald the user.

6.3.4. Average energy savings installing solar collectors for hot water

The total solar radiation energy per $1m^2$ of Danish territories is approximately 1000 kW h / year.

Using solar energy collectors we cannot get all solar radiation energy because of several reasons:

- Solar collector efficiency
  - Solar collector glass cover reflects a small percentage of solar energy
  - Solar collector has low heat loss through the side and bottom surfaces
- The performance
  - Heat losses from the system (pipes, fixtures)
  - Control system performance

The estimated amount of solar energy which can be obtained from the designed system (Figure 6.3.8) was calculated using the program offered on the website http://www.altomsolvarme.dk/kalkulator-mellem-AOS.html. The estimate generated by the program is average taking into account the medium level of solar energy collectors. Calculations show that with 72 m^2 of area and the hot water consumption of 3,600 liters per day it will be possible to produce 29,400 kWh per year with the proposed solar collectors.

Experimenting with this program we checked and concluded that, for example, increasing the solar receiver area two to three times, the energy increase would be only approximately 30%. This occurs because of uneven solar energy throughout the year. The designed system with 72 m^2 large solar collector area is optimal solution. The sun in the active months allows to provide hot water using only solar energy and the energy surplus in extra hot days is small, but in the winter months when solar activity is relatively lower, the low amount of sun energy is compensated with an additional heat source (district heating). Increasing the solar collector area two to three times the capacity of solar energy is almost enough also in winter months, but during the summer months the energy would be too much and will not be used.

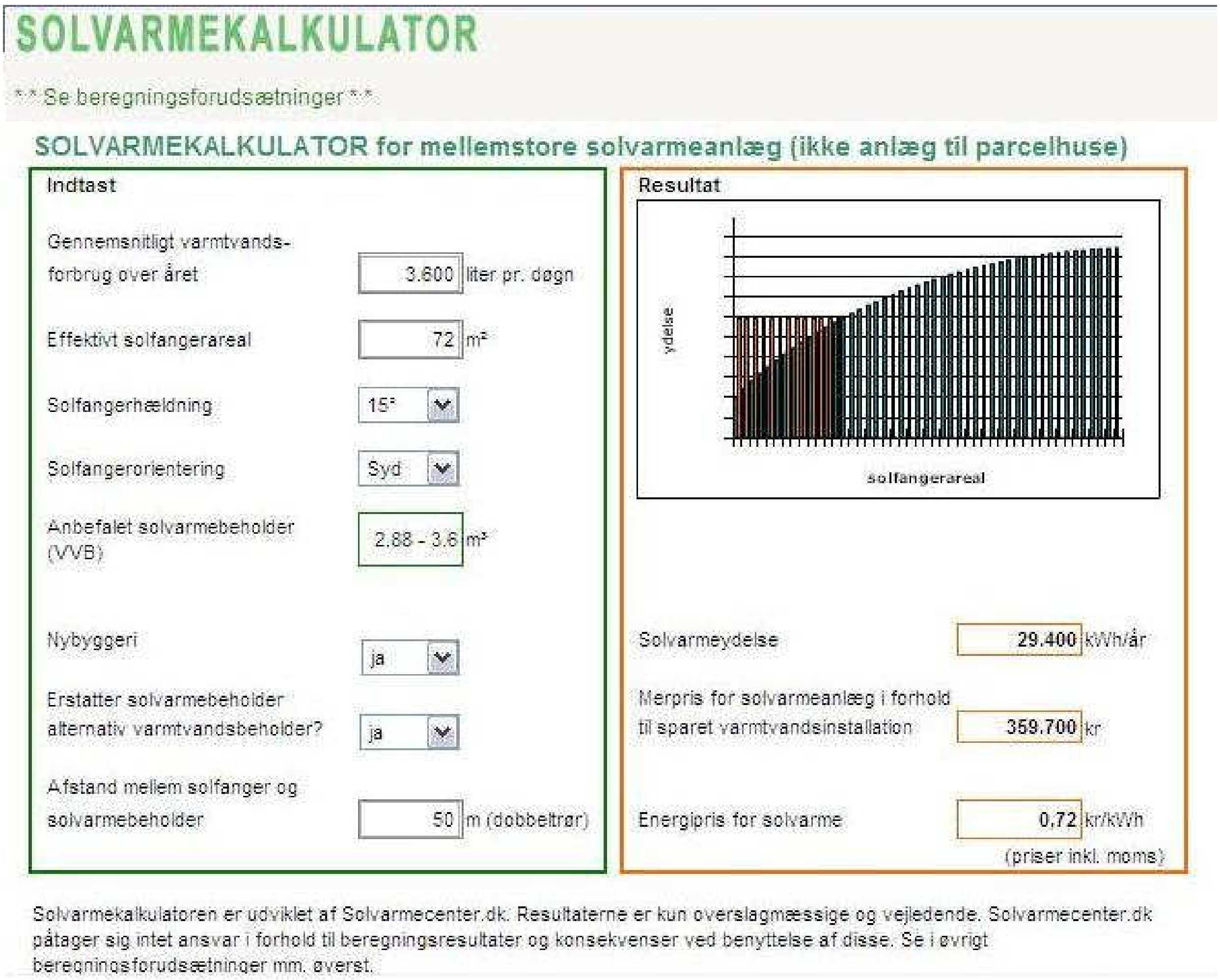


Figure 6.3.8. *Result of sun energy calculation program. „http://www.altomsolvarme.dk/kalkulator-mellem-AOS.html"*

6.3.5. Heating system

As this house is a low energy house with less heat loses, we can make innovative ideas. Cenergia's and our solution is that heating system is associated with hot water system. We connect heating system on hot water return pipe and through heat exchanger get energy for heating. (Figure 6.3.9) Most of the energy will come from district heating systems.

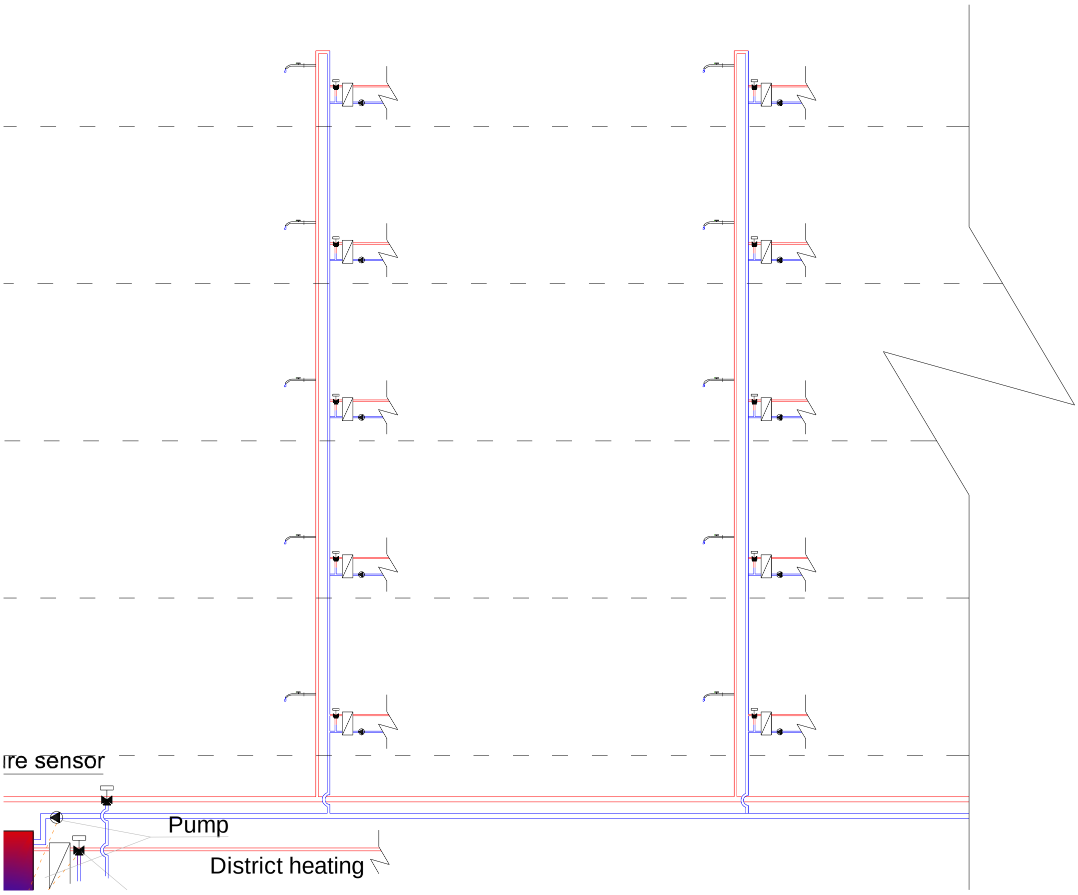


Figure 6.3.9. *Heating system.*

For this system there are advantages and disadvantages

Advantages:

- Fewer pipes
- Only one system (less costs)

Disadvantages:

- Need heat exchanger in every flat (expensive)
- For heating not so high temperature is needed as for hot water which required 50-60 °C (if we want to use heat pump for getting heat energy, the pump work is much more effective if water temperature is only till 30 °C not till 60 °C)

6.3.6. Conclusion

1. Solar energy can be effectively used for hot water but not with such great efficiency for heating purposes, as solar activity reaches its peak during the summer months, when the buildings do not require heating but still need hot water. During the winter months solar activity is relatively small and the resultant amount of energy relatively small.

2. Solar activity is very variable depending on the season, therefore the system is designed in such a way that it provides heating of 100% hot water in solar activity months, but in months when the solar activity is low the missing energy is received from the centralized district heating system. In such a way we avoid potential overheating of the system in the summer months due to the non-usable surplus energy. This is the main reason why we choose the solar collector system "Hot water preparation with the expansion tank and pressure valve". The main advantage of this system is a compact and low-power circulation pump that provides lower operating costs.
3. The other system "Hot water preparation with active drain back system" can be used effectively when it is designed with such an amount of solar collectors as to secure that all necessary amount of energy is provided by them in the months of low solar activity, but in the summer months the surplus energy does not interfere with stable operation of the system.
4. Not depending on the selected system a 72 m^2 large solar collector area can provide more than 50-60 % of the energy required for hot water for the building (approximately 29 400 kWh per year)

5. We chose Batec BA 30 solar collector for solar receivers because of the comparatively long warranty and lifetime. Although vacuum solar collectors are more efficient, their lifetime is relatively short and the price much higher.

6. It is proposed to equip the building with a non-standard combined hot water and area heating systems. It is possible because the building was designed as a low energy house and the heating energy volume is relatively small. The main advantage of this system is the reduced pipe size.

6.4.**Solar Panels Photovoltaic**

a.°) Building area

Before choosing the solar panels PV, we would like to know how many square meters it is possible to use for installing the panels. Our supervisor from Cenergia gave us the drawings about the low energy house and it is therefore possible to compute the area available. The scale was not good (1/250) so that we used a new scale for the plan.

Figure 6.4.1 : Calculate of the scale

AREALOPGØRELSE

B. Brutto/ netto

Lejl	Netto	Terrasse	Fælles	Brutto
A0	116	0	20,14	136,14 m2
B0	116	0	20,14	136,14 m2
C0	112,5	0	20,14	132,64 m2
D0	91,4	0	20,14	111,54 m2
E0	43,2	0	20,14	63,34 m2
F0	97,1	0	20,14	117,24 m2
A1	116,5	20,4	20,14	157,04 m2
B1	116,5	20,4	20,14	157,04 m2
C1	121,6	20,7	20,14	162,44 m2
D1	94,3	20,7	20,14	135,14 m2
E1	88,74	20	20,14	128,88 m2
F1	96,6	17	20,14	133,74 m2

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At the beginning, we measured one flat on the building : for example E0. This flat has a 63,34 m² gross surface and a 43,2 m² net. We used the net area to make my calculations.

On the paper the area was 2,8 cm² and the real area was 43,2 m²

➔ $\sqrt{43,2\ m^2} = 6,5726\ m$ $\qquad$ $\sqrt{2,8\ cm^2} = 1,6733\ cm$

6,5726 *m => ?*

1,6733 cm => 1 cm *657,26 cm / 1,6733 cm = 392,8 cm*

We have the new scale and it is a 1/400 scale. Now we can find the available area and how many square meters we have to install the solar panels PV.

With this page, I measured the number of area, I can used for my part and if it is enough for win electricity :

Figure 6.4.2 : *Area of the building*

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We have eight different areas and here is what we computed :

- [(1,6 x 4)x(1,2 x 4)] + [(1 x 4)x(1 x 4)] + [(1,1 x 4)x(2,9 x 4)] + [(2,9 x 4)x(1 x 4)] = 118,72 m²

- 118,72 + [(2,4 x 4)x(1 x 4)] + [(2,3 x 4)x(1 x 4)] + [(1 x 4)x(1 x 4)] + [(2,3 x 4)x(1 x 4)] = 246,72 m²

  It is impossible to take all these different areas because we want to install some solar panels for hot water, therefore it is crucial to share and we will use this areas for my installation:

  Figure 6.4.3 : *Using for solar panels*

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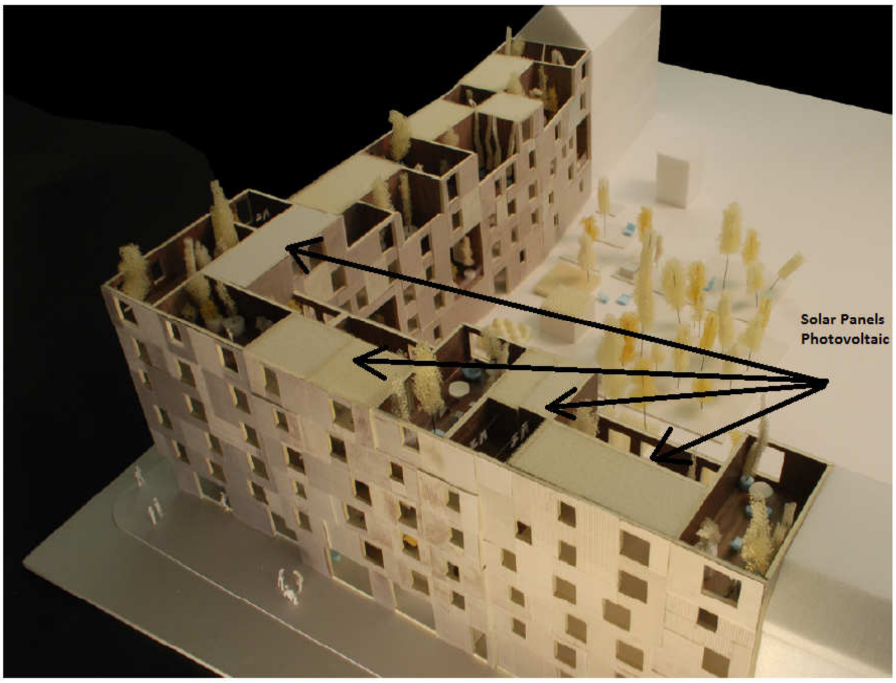


- [(2,4 x 4)x(1 x 4)] + [(2,3 x 4)x(1 x 4)] + [(1 x 4)x(1 x 4)] + [(2,3 x 4)x(1 x 4)] = 128 m²

I know now how many square meters I have and I can choose the best solar panel photovoltaic for my installation.

B°) The optimal angle :

The formula for an optimal angle is :

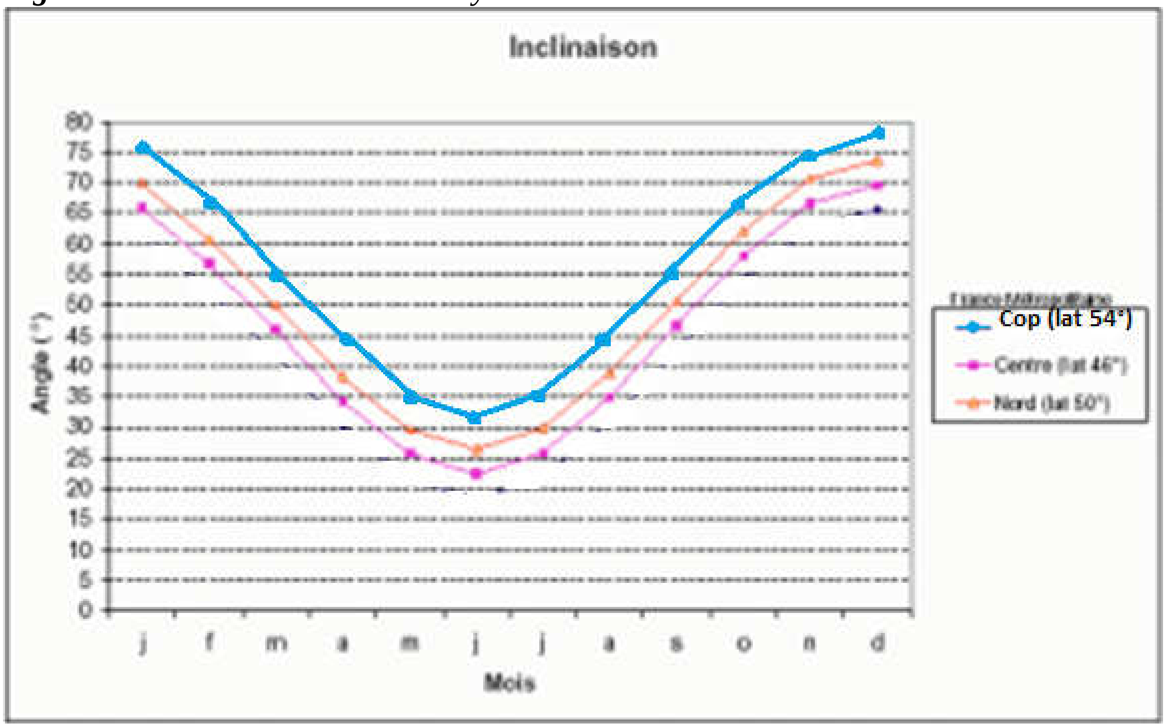
$$optimal\ angle = (latitude\ of\ the\ site) - \sin^{-1}\ [0{,}4 \times \sin\ (N \times (360 \div 365))]$$

- Latitude of the site : We can observe a variation more or less about 27° (that is 55° amplitude during one year) against at the latitude of the site. This angle is exactly to the earth angle.
- N : Number of negative temperature days between the vernal equinox and the first day. In Denmark, the first negative temperature appears in January.

$$optimal\ angle = (27^{\circ}) - \sin^{-1}\ [0{,}4 \times \sin\ (251 \times (360 \div 365))]$$

$$= 28^{\circ}$$

Figure 6.4.4 : *Inclination while one year*



http://www.econologie.com/photo/solaire_autoconstruction2.gif

On this diagram, we can see the best inclination each month in different place. In the north the angle is higher and we can start during January at 75°.

This formula is good when you can move the solar panels during the year and change the angle of the panels. For our project, we cannot change the angle for economic reasons and we will try to find the best angle between 30° and 35°.

On this website I choose one of them "http://www.solaraccess.fr/produits/panneaux-solaires.html". I took a monocrystalline solar panel because it is better for a country like Denmark and mainly because this one has a good efficiency.

C°) Choice of the solar panel :

Solar Panels SHARP_NU-E235 (E1) 235 Wc :

Table 6.4.1 : *Solar panel*

Peak power	235 Wc -5 +10%
Dimensions	1,652 x 994 x 46 mm (1,64 m²)
Efficiency	14,3 %
Weight	20 kg
Production Guarantee	25 years
Connection type	Cable with plug connector (MC-3)

(You can see more information appendix 1)

Actually with this formula : "Pc = 1000 x S x R" you can calculate the peak power

Pc : is the peak power (W)

S : area (m^2)   R = efficiency (%)

1000 : the common sunshine without atmosphere.

But in this country (Denmark) the common sunshine is not 1000 but 800, so we have to calculate again the new peak power.

Pc = 800 x 1,64 x 0,143 = 187,616 W which is approximately 187 W

Normally on average, we can write this formula " 1 m^2 PV $\sim 100\ W \sim 100\ kWh/m^2$/ year "

Then, I calculated the total area we can use (128 m^2) but we have many areas and we need to be careful because I cannot divide the total area by the square of one solar panel.

I have three different places : 16 m² and you can put (16 / 1,64 = 9,75) 8 solar panels on this area

38,4 m² and you can put (38,4 / 1,64 = 23,4) 18 solar panels

36,8 m² and you can put (36,8 / 1,64 = 22,43) 18 solar panels.

In overall, we have in totally 62 solar panels photovoltaic.

I can calculate the energy we can get with 62 solar panels :

1,64 m² x 100 Kwh/m²/year = 164 Kwh/panel/year

164 x 62 = 10,168 Kwh/year

2.°) Choice of the lamp.

On average a home with four people can use 560 Kwh/year for a bill about 50 euros or 372 DKK.

You can install each lamps in each rooms because each lamps are a speciality.

- A LED for a bedside light in a bedroom
- A compact fluorescent lamp for the living room
- An incandescent light bulb for the corridor
- A solar lamp for the garden

When you compare power between this kinds of lamps, you can see a incandescent light bulb consume a lot of power :

Table 6.4.2 : *Compare the kinds of lamps*

Compact fluorescent lamp	Incandescent light bulb
9 watts	30 watts
11 watts	40 watts
15 watts	60 watts
20 watts	75 watts
23 watts	100 watts

Table 6.4.3 : *Compare price of lamps*

	Compact fluorescent lamps	**incandescent light bulb**
Life span	8000h	1000h
Number of lamps used for 8000h	1	8
Price for one lamp	10 €	0,50 €
Price of the Lamps for 8000h	10 €	8*0,5 = 4€
Electric power	20 W	75 W
Energy consumed during one hour	0,020 kW.h	0,075 kW.h
Energy consumed during 8000h	0,020*8000 = 160 kW.h	0,075*8000 = 600 kW.h
Energy price for 8000h	160*0,105 = 16,8 €	600*0,105 = 63 €
The total price for 8000h of lighting	10 + 17 = 27 €	4 + 63 = 67 €

Why I want to take LED's ?

- When I buy this kind of lamp, I respect the environment and the sustainable development of the earth (98 of materials used are recyclable).
- We can save money about 85% by the reduction of the energy consumption.
- We can put this lamp everywhere.
- We can choose the colour of our lighting.
- It is safe for our health.

So I think we will take just LED or Compact fluorescent lamps for our project, it is maybe expensive but it will be a good investment because you can pay off very quickly.

Conclusion :

After look for some information about the weather, the solar panels and the lights I can say now, it will be good to install a solar system photovoltaic because we can get electricity. Indeed the Denmark is a country which we can develop the new renewable energy.

6.5.Automatic systems

6.5.1. Budget

Because it is difficult to find prices on products we need, we decided to get in touch directly with suppliers in order to calculate the budget in our home.

After contact with staff support from Schneider Electric, through the email address Es-soportetecnico@es.schneider-electric.com, we recieved the document "tarifa-mecanismos-contro-knx2010.pdf", which attached in the Annex.When asked what the budget is for the installation, we reply that they must add 10% to final price.

With these data, we have to make the budget on our home automation facility, as shown below:

Product	Description	Reference	Price/unit	number	price
1.1.-Automatically manage lighting by detecting moving in home.					
Unica	Motion sensor switch 300 W	U3.524.12	111,3	14	1558,2
Unica	Pushbutton NC	U3.236.18	0,498	90	44,82
1.2.- Ensure efficient lighting at the entrance to our block of flats.					
MINp	Electronic timer	CCT15234	13,98	6	83,88
C60N	1-pole circuit breaker	24312	0,498	18	8,964
Unica	Pushbutton NC	U3.236.18	0,498		0,498
2.1.- Temperature control via thermostatic valves					
Domótica RF	Connect Central RF.	MTN505919	701,1	18	12619,8
Domótica RF	thermostatic valves	MTN509201	98,98	36	3563,28
3.1.- Identify sources of excessive consumption					
EN40	kWh (kilowatts per hour) meter	15238	75,98	18	1367,64
C60N	2-pole circuit breaker	24339	0,798	36	28,728
3.2.- Security and continuity of service in front of atmospheric phenomena.					
Quick PF	Surge Limiter Automatic Type 2	16617	51,98	18	935,64
4.1.- Garden watering control					
K60N	2-pole circuit breaker	27913	0,798	18	14,364
IHP + 1C	Digital time switch	CCT15721	15,9	18	286,2
CT	Contactor 2 pole	15959	0,613	18	11,034

components	20523,048
instalation	2052,305
Total in euro:	22575,353
Total in DKK:	3034,353

Figure 6.5.1.- *budget on our home automation facility.*

So finally the total price of the installation will be 3034.3 DKK , regardless of the rest of the electrical installation. Given that we arrohar up to 10% of the energy, the payback period is very short, due to low investment.

Conclusions

Most analysts do not hesitate to point out that the biggest challenges for home automation will be the simplicity and respect for the environment. Two issues those undoubtedly strike too close.

In no case, the home can become a complicated control room; its inhabitants must be able to use them naturally. No point the user to find a technically acceptable but that in practice, it produces confusion, and as a result of the foregoing, rejection and fewer still that high energy and environmental cost nullifies the enjoyment of the living in a comfortable home.

The total price of the installation will be 3034.3 DKK , regardless of the rest of the electrical installation. Given that we can save up to 10% of the energy, the payback period is very short, due to low investment.

7. CONCLUSION

This project was very interesting for all of us. It enables us to work on different subject such as building insulation, ventilation system, heating system and solar energy. All of us were very interested in low energy building and all of us choose different aspects of the subject due to our different fields of study. Working in an international team was a very good experience and a very good practice for increase our English level.

The main objective of our project was to design a building for make it reach the class 1 Danish standard in order to considerate this building as a low energy building. Through different aspects of the project, we learn how to decrease the energy consumption of the building. With an efficient heating system, building insulation and ventilation system we can reduce the amount of energy needed and solar panels photovoltaic generate energy in order to reduce the consumption of district energy.

After studying the Danish climate, we were able to imagine a solar panel system for the building. Because of the unusual shape of the building, we did not have a lot of space on the roof. But we still design it and calculate the amount of electricity we can get. We also had to calculate the best angle in this country in order to get the maximum amount of electricity possible.

We also had a look about the lighting system, by gathering information about different kinds of lamps. And try to choose the more efficient one with a low consumption, long lifetime, and money saving.

For the building insulation we had to make several research about the different types of insulating materials. This market is actually well develop and we can find some common materials with a good efficiency, a low price and ease of use and installation. A good insulation enables us to have a large decrease of energy consumption of heating system and it also make this building have good living condition.

The heating system we choose use both solar energy and district heating. By using solar captor for warm up the water it help once again to reduce energy consumption. The efficiency of solar captor depend of the climate but supply a good amount of hot water. The district heating is only use as a security for hot water supply, if the solar captor system don't generate enough hot water.

With the introduction of home automation components, we have the house more comfortable, friendly, and respecting the environment, but without turning it into a complicated control room. The total price of the installation will be 3034.3 DKK , regardless of the rest of the electrical installation, and the payback period is very short, due to low investment.

In order to prevent the Sick Building Syndrome (SBS), toxic pollution from chemical substances, dust, accumulation of microbes, bacteria and viruses, and reduce the exposure to allergens, we are going to use a ventilation systems. Ventilation investment in the system is very low and very high savings, up to 66%, so the investment is recovered quickly.

Through those different systems we are able to reach the class 1 Danish standard. Such reduction of energy consumption needs a bigger investment and the payback can be long like, for example, solar panels. But it is a good opportunity to change behaviour because this building can have a very good level of life and waste the minimum energy possible. Through our different field of study we were able to have different point of view and different idea for this project. But in order to waste minimum energy, it is needed to change behaviour. The best way to save energy is to stop the waste of energy in the everyday life. This building is optimized for save energy but it is the consumers who have a big role to play for reduce energy waste through electricity, hot water and electrical devices.

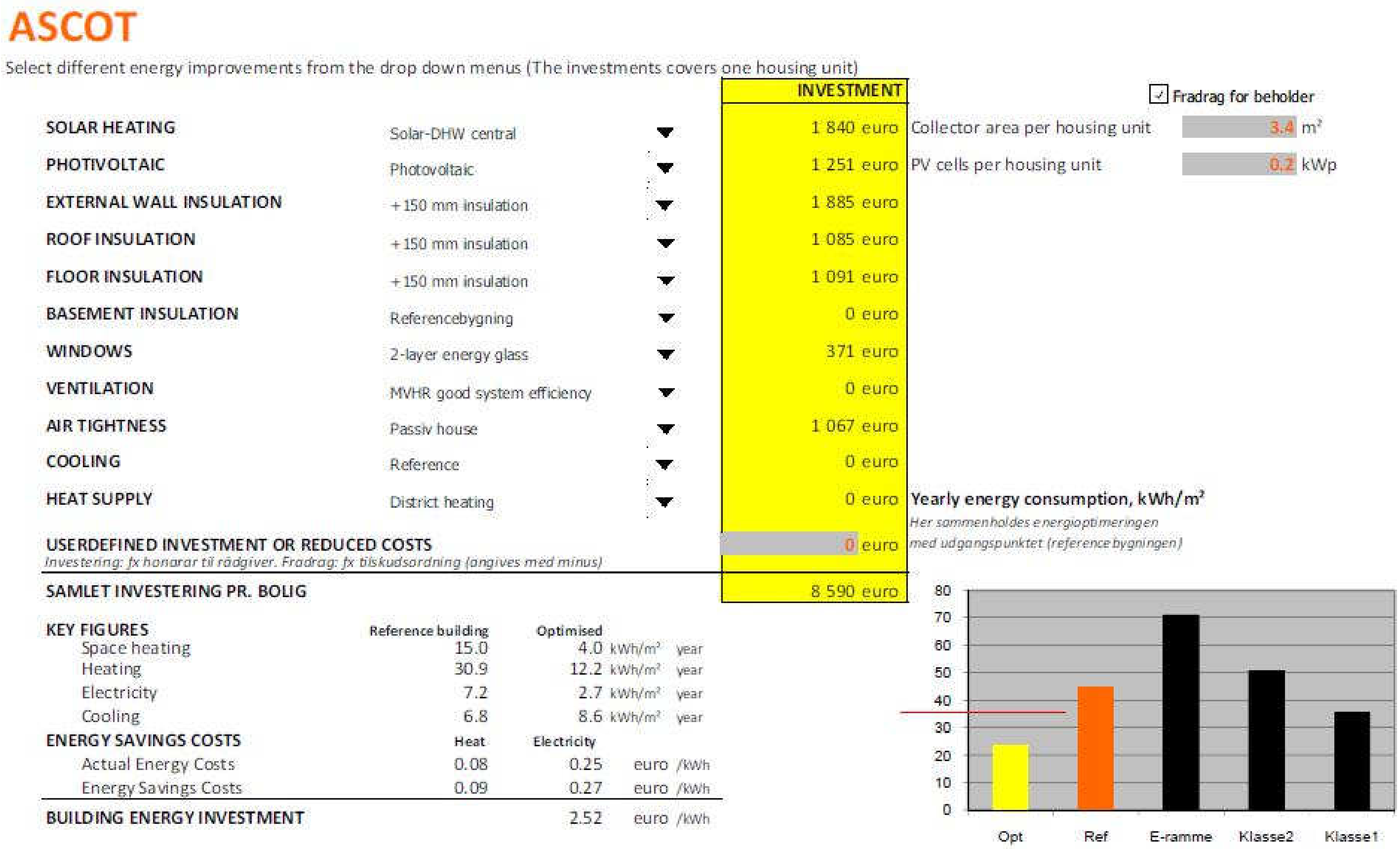


Figure 7.1. *ASCOT calculation for energy consumption and investment [ASCOT](#)*

By using the ASCOT program calculation we can be sure that this building with our technological solution selection is able to reach the class 1 Danish standard.

8. References

Books:

1. 1998, 1999, 2000, and 2001 ASHRAE Handbook CD

Internet resources:

1. http://www1.eere.energy.gov/buildings/commercial/water_heating.html
2. http://extras.mnginteractive.com/live/media/site36/2005/1023/20051023_021546_Zero%20Energy%20Home.swf
3. http://www.nrel.gov/buildings/zero_energy.html
4. http://www.energymap.dk/
5. http://www.passivhaustagung.de
6. http://www.dti.dk
7. http://www.volker-quaschning.de/articles/fundamentals4/index.php
8. http://en.wikipedia.org/wiki/Solar_water_heating
9. http://www1.eere.energy.gov/solar/sh_basics_collectors.html#flatplate
10. http://www.altestore.com/store/Solar-Water-Heaters/Differential-Temperature-Controllers/Delta-T-Hardwired-AC-Differential-Temperature-Controller/p6836/
11. http://www.solorb.com/elect/solarcirc/diftemp2/
12. http://www.freeinfosociety.com/electronics/schemview.php?id=2127
13. http://www.resol.de/index/produkte/kategorie/1/sprache/en
14. http://www.batec.dk/
15. http://www.altomsolvarme.dk/
16. http://www.solenergi.dk/SEC/visTekst.asp?id=62
17. http://www.solarenergy.org/
18. http://isolation.comprendrechoisir.com
19. http://www.fao.org
20. http://www.energy.ca.gov

21. http://homerenovations.about.com
22. http://forums.futura-sciences.com/electronique/223283-puissance-delivree-un-panneau-solaire.html
23. http://www.solaraccess.fr/produits/panneaux-solaires.html
24. http://www.commentcamarche.net/s/comment+calculer+puissance+d+un+panneau+solaire
25. http://www.quelleenergie.fr/travaux_equipements/panneaux_solaires_photovoltaiques/installation
26. http://goscandinavia.about.com/od/denmar1/ss/weatherdenmark.htm
27. http://www.wordtravels.com/Travelguide/Countries/Denmark/Climate
28. http://images.google.dk/imgres?imgurl=http://www.weather-and-climate.com/uploads/average-sunshine-denmark-karup.png&imgrefurl=http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Karup,Denmark&usg=__PIqbymMYPaXNZ1pUoEY9vOemog8=&h=232&w=702&sz=25&hl=da&start=1&um=1&itbs=1&tbnid=AW3P1Uo5pywirM:&tbnh=46&tbnw=140&prev=/images%3Fq%3Dsunshine%2Bdenmark%26um%3D1%26hl%3Dda%26sa%3DN%26tbs%3Disch:1
29. http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Karup,Denmark
30. http://en.wikipedia.org/wiki/LED_lamp
31. http://www.pratique.fr/10-gestes-essentiels-economiser-energie.html
32. http://www.securikids.fr/parents/famille/droits-de-lenfant/208
33. http://www.letoitangevin.com/-Conseils-pour-economiser-l-energie-
34. http://www.econo-ecolo.org/spip.php?article1313
35. http://sciencesphy.free.fr/DeveloppementDurable/PetitsGestes/ComparatifLampes.htm
36. http://sciencesphy.free.fr/DeveloppementDurable/PetitsGestes/ComparatifLampes.htm

37. http://www.destek-yazilim.com/Galeri/Merloni.htm
38. http://www.schneider-electric.dk/sites/denmark/da/generalt/kontakt/kontakt.page
39. http://www.globalwarmingart.com/wiki/File:Incandescent_Light_Bulb_png
40. http://www.artestuff.com/index.php?cPath=3_11&osCsid=0d2aba2f013fe94564bb68fac6a4800a
41. http://www.schneiderelectric.es/documents/local/soluciones/Guia-soluciones-eficiencia-energetica-2a-edicion.pdf)
42. http://www.nibe.co.uk/NIBE-Heat-Pumps/Exhaust-air-heat-pumps/
43. http://www.soloheatinginstallations.co.uk/heat_recovery.htm

9. Appendix 1

10. Appendix 2

11. Appendix 3

12. Appendix 4