Bolig for livet - Home for life
- energi, æstetik, komfort - med mennesket i centrum
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Energy, aesthetics and comfort – with humans in the centre
»One test is worth more than 1000 expert assumptions«
Villum Kann Rasmussen

Therefore we are building real houses and trying things in practice. The purpose is to develop new knowledge about energy efficiency, comfort and aesthetics of future houses. The houses will therefore be tested by a family for a period of one year.

CO₂ emissions shall be reduced
Scientists have confirmed that in 40 minutes, there is enough sun energy on the earth's surface to cover the world's energy use for a whole year. Good information in a time where climate changes develop faster than we have expected. But it requires that we are able to harvest the sun – and on a much bigger scale develop and make use of new technologies.

The way we build and live has a large meaning for saving the environment in our everyday lives. Energy use for construction and operation of buildings in the West makes up about 40% of the total energy use – energy that is primarily based on coal and in that way is connected to high CO₂ emissions. There is a large challenge in developing the future building structure in such a way that it optimizes the use of sun energy and decreases the CO₂ emissions.
Active House

In Home for Life the idea of an active house is made visible, and the house is a living manifestation of a flexible and healthy environment. The house is designed so that it can adapt to changes in lifestyle and needs, and it is equipped with a wide range of smart and intelligent systems that optimize energy use, comfort, and health.

The house is designed to be energy-efficient and sustainable, with a focus on reducing energy consumption and maximizing energy production. The house is equipped with solar panels, energy-efficient windows, and smart home technology that allows for remote control and monitoring.

The house is also designed to be healthy, with a focus on indoor air quality and the use of non-toxic materials. The house is equipped with a ventilation system that ensures fresh air circulation, and the use of natural materials and colors creates a healthy and relaxing atmosphere.

In summary, the Active House is designed to be a living manifestation of sustainable and healthy living, with a focus on energy efficiency, comfort, and health.
From archetype to active house

- We use the archetype of a 1½ story saddle roof house with traditional insulation.
- We stagger the peak to make space for a big energy producing roof surface facing south. The house is well insulated and air sealed.
- We open up for daylight, fresh air and view. The area of the windows is 40% of the floor area.

Home for Life – energy concept

- Solar cells, solar heating and heat pump produce electricity, hot water and room heating.
- About 50% of the room heat consumption is covered by the passive sun heat from the energy optimized windows.
- Natural and mechanical ventilations as well as in- and outside sun screens ensure fresh air and a good room temperature.
- The control system for the house reduces the energy consumption and ensures a good indoor climate.
In Home for Life more energy is produced than consumed – and all energy is renewable.
Energy

The energy goal for Home for Life is that the house is self-sufficient with energy. It produces more energy than consumed, and calculated according to Beat 2010, the energy for erecting the house will be paid back within a 30-50 year period. The graph below shows that the house will be paid back over approximately 40 years.

Daylight

The state of daylight is optimized to reduce consumption of electric light. The window area amounts to 40% (against normal 20-25%), and the windows are placed in all 4 facades as well as on the roof to ensure a good natural light, distributed deep into all rooms. The daylight intake and good coupling and fixing possibilities, installed with 3-layer energy glass. The roof overhang facing south show that the house will be paid back over approximately 40 years.

Electricity production

The solar collectors cover 50-60% of the yearly household hot water heating. Solar collectors are also used as a supplement to room heating. Solar collectors make up an area of 6.7 m² and are integrated in the lowest part of the roof surface.

Material energy

Material energy is estimated in the extension programme Beat 2003. Data has been collected for use in Beat (data processing according to UMIP method) for the components

Control of the house reduces energy use

The house is managed in such a way that the use of electricity and heat is minimized. In the summer the automatically controlled solar ventilation is used for airing the rooms. During the heating season mechanical ventilation with heat recovery is used so the cold air can be heated without losing the addition energy. Intelligent controls regulate the outdoor and indoor solar screening for optimizing warmth and light intake as well as putting off the lights when the room is not in use.

Household hot water heating

The solar collectors cover 50-60% of the yearly household hot water heating. In addition, solar collectors are also used as a supplement to room heating. Solar collectors make up an area of 6.7 m² and are integrated in the lowest part of the roof surface.

The heat pump construction supplements the remaining parts. The heat pump functions by absorbing energy directly from the surrounding air by an air module that is placed outside the house. The heat pump is an interesting solution in connection with solar collector systems because it is more energy efficient and has a lot less CO₂ escape than e.g. oil or electric heating. The installed system is able to combine the energy from the solar collector system with the heat pump in an optimal way and by this, reduces the annual system expenses.

Energy production

An energy-rich house for Life for Life comes directly from the sun:
- The solar collectors produce hot water for household use.
- The solar collectors produce room heating and supplements hot water for household van.
- The solar cells generate electricity for the house.
- Energy efficient windows with low-uv-value ensure the supply of passive heat.

Room heating

About 50% of the room heating needs are covered by the passive solar heating. The rest is coming from a combination of floor heating and radiator heating. Floor heating is used in all common rooms and radiator heating in the bedrooms, so that the heat in these rooms can be regulated quickly. The heat circulates around the house by energy saving pumps. The design is made in such a way that the transmitting pipes are made as short as possible to avoid heat and pressure loss. The inlet temperature is kept as low as possible to ensure high efficiency of respectively the solar panels and the water pump heating, this is done to ensure lowest possible heat loss in the installations.

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Material energy

Material energy is estimated in the extension programme Beat 2003. Data has been collected for use in Beat (data processing according to UMIP method) for the components where it was possible. For other components, corrected producer’s data has been used along with data for similar components.

The house in Home for Life is optimised to ensure a good natural light, distributed deep into all rooms. The daylight intake and good coupling and fixing possibilities, installed with 3-layer energy glass. The roof overhang facing south is carried out to ensure good natural light, distributed deep into all rooms. The solar receivers are integrated in the lowest part of the roof surface. The solar surface facing south makes shade for a high summer sun and gives access for a low winter sun. Shutters and sun blinds regulate heat, light intake and privacy when needed.

Daylight

The state of daylight is optimised to reduce consumption of electric light. The window area amounts to 40% (against normal 20-25%), and the windows are placed in all 4 facades as well as on the roof to ensure a good natural light, distributed deep into all rooms. The daylight intake and good coupling and fixing possibilities, installed with 3-layer energy glass. The roof overhang facing south is modulated via simulations in VELUX Daylight Visualizer and model studies in a light lab.

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Energy regulation codes
Energy use in Home for Life conforms to a low energy class I. But in contradic-
tion to other regulation codes Home for Life produces its own energy.

In Home for Life, there is more daylight, fresh air and contact between inside and outside, because the window area is almost double the area of that of a single family house. The house produces the energy that is consumed and therefore there is no energy expense or impact on the environment. In Home for Life there is a healthy and comfortable indoor climate and the interaction between energy, comfort and aesthetics creates an archi-
tectural composition. Since several of the energy technologies and energy optimising build-
ing components are not yet on the market, Home for Life is more expensive to build than a traditional house today.

Differences between Home for Life and a traditional single family house

Energy use for heating in Home for Life is about 50% of the energy use in a normal newly built house following the Danish requirements for new buildings in BR2008.
Comfort
The house of the future shall be pleasant to live in and around. It must not be too warm in the summer and not too cold in the winter. It should be flexible so that it gives space for both togetherness and for peace and quiet. It should be easy to maintain and use.

Ventilation
There is a lot of fresh air in Home for Life. In the winter the air enters in via the mechanical ventilation system that at the same time ensures that the warmth from the exhaust is reused. The equipment is programmed so that it adapts to the ventilation needs in the room. The air is circulated into the »living« rooms (bedroom and living room) and exhausted from the utility rooms (kitchen, bathroom, laundry room).

In the summer fresh air enters through natural ventilation that is controlled by a sensor in the house so that it is ventilated more than necessary and at the same time, maintains a good indoor climate. The natural ventilation replaces the mechanical system with the result of energy savings.

In Home for Life comfort is obtained by the help of an active facade. The active facade changes according to the seasons and needs. It can either be open to let the light and warmth in, or it can be closed to screen against the sun and maintain warmth during the night.

The house is healthy and comfortable to live in as long as the house is healthy and comfortable to live in

Plenty of natural daylight, fresh air and good materials ensure that the house is healthy and comfortable to live in.
Life, light and air reflected in the architecture
Aesthetics

The principal architectural idea in Home for Life is to unite single-family house requirements to experience, functionality and energy consumption in an integrated design. It is the light incidence, the active facade, the relationship between in and out and the flexibility of the house that gives the high architectural quality.

The arrangement of the house

Home for Life is designed with good space for both togetherness and peace and quiet. Emphasis is placed on creating special places for active experiences and flexible situations. The house is located on the north-west part of the lot to give the best possible space for gardens as well as utilise the height of the lot against north. The building appears as a total, sculptured building body where the carport and outbuilding are integrated. The house makes use of the zoning plan’s possibility for building in 1½ stories which also contributes to optimise the view from both lot.

The Facade

The choice of slate covering on the facade and roof reflects both the wish for durability, low CO₂ influence and minimal maintenance, but also the wish to integrate the dark surfaces of the solar cells, the solar panels and the windows in a sculptural composition. The wood covering and wood flooring, with their feeling of natural warmth, give a contrast to the hardness and cold expression of the slate.

Dissolution of borders between inside and outside

In the Home for Life the borders between inside and outside are dissolved. The windows and patio doors that reach to the floor make inside and outside flow together so the room appears larger and more airy, while the windows that go completely to the ceiling together with the skylights, ensure that the daylight comes deep into the rooms.

The relation between inside and outside is maximised and related to several activities in the house. From the laundry room there is a direct entrance to the covered and semi-insulated »multi-house« where vegetables can be stored, clothes can be dried under a roof and bicycles repaired.

From the kitchen/family room, there is direct access to both the patio with morning sun to the east, the covered patio facing south and the active climate zone to the west. Also from this room on the first floor there is access to the outside. From the large south-facing patio there is a clear view over the Aarhus Bay. From the bedroom facing east there is an access to a smaller east-facing patio over the »multi-house«.

Daylight

The use of light as sensory and ambient elements is the foundation for the composition in Home for Life. The house is organized around a right-corner which provides light from all four sides. The main part of the rooms in the house have windows that face in at least two directions which besides being a source of light, also functions as an exit, ventilation opening, seating recesses, work place or as a frame around a view.

The placement and the size of the windows are harmonious with the position of the sun in the sky, seasons, energy optimization and the needs of the residents in the house. The large insulation thickness and the pitch of the roof creates a natural overhanging facing south that provides comfortable sun screening without destroying the view. Besides this, glazing is avoided with integrated screening both inside and outside.
Light creates space

Kitchen/family room

The facade is open towards the south with a common window section that is vertically divided into five sections. The small upper window sections provide automatic ventilation via the WindowMaster control system. Two of the windows function as patio doors and provide access to the south-west patio. Because the window section reaches from the floor to the ceiling, it seems that the rooms continue out to the patio. The horizontal cut-off of the roof overhang creates a shadow for the southern sun and prevents overheating. Two very large square window sections are placed opposite each other facing to the east and west.

Two skylights are placed in the kitchen/family room, one in each corner of the south-facing ceiling. The windows are placed far out to the sides not the ends of the rooms facing east and west and go the whole way up in the light funnel without crossing the ceiling. Without standing on the balcony or on the top of the stairs on the first floor, the skylights provide a view over the bay in the distance.

The southern facade windows and skylights generate a large amount of passive solar heat, which contributes to the positive energy balance of the house. In order to avoid overheating in a warm summer day it is important that the windows can be screened.

The skylights are therefore fitted with outer electric sun-blinds that can reduce the heat accumulation from the sun by up to 90% and also contribute to improve the insulation value of the windows. Electric window blinds are fitted on the interior which makes it possible to adjust the quantity of daylight in the room and further improves the insulation value. Sun-blinds and curtains are operated electrically by io-homecontrol which also controls the climate comfort and thereby ensures that it is not too warm in the room. The skylights, sun-blinds and curtains are operated by solar cells and generate the energy themselves which is necessary for operation.

From the room it is possible to see the skylights facing north in the kitchen and bathroom on the first floor. The view along the large characteristic sloped ceiling surface together with the north light in the room from here contributes to the fact that the room has a very diversified and differentiated daylight impression where there is light from all four corners of the world and from the sky.

Living room

The room opens facing south with a glass facade consisting of four window sections, of which two function as patio doors to the large covered patio. Over the doors there are solar ventilation windows that open automatically and drive in fresh air as needed. The windows extend from floor to ceiling which makes the patio outside seem to be a part of the room. The covered patio protects against the warm southerly sun.

The room gets daylight from three different directions: cool north light through the skylights, warm sunlight through the large window sections facing south, together with the high and low placed west windows. The south facing panorama window opens to the view over the Aarhus bay. Facing south the roof overhang provides screening for the high sun in the summer months.

The facade and roof windows have solar screens and inner electric curtains.

Bedroom 1

This room has two high placed roof windows facing north and a combined VELUX facade and skylight section built in at a lower height. The facade section goes all the way to the floor and provides for daylight reflection into the room all the way down to the floor level.

The inside glass section above the wall facing south provides light from the kitchen/family room. The skylights are fitted with outer blinds. Black-out curtains are mounted on the windows.

Bedroom 2

This room has two high placed roof windows facing north and a combined VELUX facade and skylight section built in at a lower height. The facade section goes all the way to the floor and provides for daylight reflection into the room all the way down to the floor level.

The inside glass section above the wall facing south provides light from the kitchen/family room. The skylights are fitted with outer blinds. Black-out curtains are mounted on the windows.

Bedroom 3

This room has two vertical window sections oriented to the east that give the possibility of direct morning sun. The one window functions as a door to the east facing patio. The windows from the view over the mountains of Mols. An inside window in the east window enunciates light form the large south facing skylight in the kitchen/family room.

Living room

VELUX roof windows

Two fixed lights with blinds and internal automatic roller blinds (facing east).

Two fixed lights and two fixed lights with internal automatic roller blinds (facing south).

VELUX roof windows

Two centre-pivot roof lights with solar operators, black-out blinds and awning blinds.

One facade light and one centre-pivot roof light with manually operated black-out blinds (facing north).

Bedroom 1

VELUX facade windows

One fixed light and one opening light with lining and internal automatic roller blinds.

One facade light and one opening light with lining and internal automatic roller blinds (facing east).

One fixed light and one opening light with lining and internal automatic roller blinds (facing north).

VELUX roof windows

Four centre-pivot roof lights with solar operators, opening blinds and roller blinds.

Bedroom 2

VELUX roof windows

Two centre-pivot roof lights with solar operators, black-out blinds and awning blinds.

One facade light and one centre-pivot roof light with manually operated black-out blinds (facing north).

VELUX roof windows

Two fixed lights with blinds and internal automatic roller blinds (facing west).

Two fixed lights and two fixed lights with external automatic roller blinds (facing south).

VELUX roof windows

Two centre-pivot roof lights with solar operators, black-out blinds and awning blinds (facing north).

Bedroom 3

VELUX facade windows

One fixed light with lining and internal automatic roller blinds (facing west).

Three fixed lights in the middle with one fixed and two opening lights on top. The two opening lights are motorised. Two patio doors with fixed lights on top. Motorised automatic roller blinds (facing south).

One fixed light and one patio door with a motorised opening light on top. Linkages with internal automatic roller blinds (facing east).

VELUX roof windows

Four centre-pivot roof lights with solar operators, opening blinds and roller blinds.

Kitchens and family room

VELUX facade windows

One fixed light with lining and internal automatic roller blinds (facing west).

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VELUX roof windows

Four centre-pivot roof lights with solar operators, opening blinds and roller blinds.
Materials

The materials in the house have been chosen with a focus on them being as least harmful to the environment as possible. A large amount of natural materials are used which have a high durability and require a minimum of maintenance and contribute to a good indoor climate.

Sonnenkraft Solar Complete

Solar Complete is a unique combination of sun heat and heat pump technology where the sun is the driving force in the construction. Solar collectors catch not only the direct sunlight but also the indirect sunlight so it has a good effect even on a cloudy day. If there is a lot of sunlight, warm water will be transferred directly to the tank and the heating is completely free. On the other hand if it is cloudy or only partly sunny, the heat pump comes into function. The heat pump collects energy either directly from the air or from a combination of the air and the warm water from the solar collectors.

It is the combination of the heat sources that makes the system unique. Heat pumps have an operating temperature where they are most efficient and by supplementing solar heat to reach the most optimal temperature, the highest possible effectiveness and the lowest possible cost for heating can be ensured.

WindowMaster

WindowMaster supplies natural ventilation for Home for Life. Natural ventilation regulates the indoor climate of the building with the help of controlled air change through the windows. In Home for Life the air can be utilized optimally, because all rooms have windows in more than one direction and there is a high ceiling in some parts of the house. The height in the house helps to create thermal lift with large energy savings as a result. The WindowMaster system includes advanced motors built into the window profiles, together with intelligent controlling of natural ventilation. Natural ventilation is automatically controlled so the house airs itself out after predetermined time intervals. There is also the possibility to operate the system manually.

External

Roof surfaces: Kangrobes natural slate, Giss Roter collar tiles, VELUX solar panels and solar collectors.
Facade: Kangrobes natural slate. Dinesen Douglas slats used as solar screening for windows. VELFAVIC tiles windows.
Pavels: Kangrobes natural slates. Concrete paving stones with Bornholm mosaic stone mosaic.

Internal

Floors: Kangrobes natural slate in the kitchen/family room, entrance, with room stair in the ballroom on the main floor. Dinesen Douglas planks in the bedroom and living room. Cast tiles of reused glass from Fliseuniverset on the 1st floor.
Walls and ceiling: Generally flat white surfaces. Dinesen Douglas planks around the »core« of the main floor.

Kitchen:


Bathroom on the 1st floor:

Cabinets from Carasso. Mosaic tiles made of natural slate from Fliseuniverset. Faucets from Damixa. Louis Poulsen.

Construction

The house is built of a light wood construction with load-bearing I-beams in wood and beams/Joists in laminated wood. In special strained areas, steel beams are used where necessary. Stability and slice effects are obtained with the use of plywood mounted on the facade on the roof and outer walls. Corbels around the balcony and utility room on the 1st floor are built with laminated wood as load bearing. The corridor over the kitchen/family room is built as a steel frame.

Linear thermal transmittance

To minimize the thermal loss in the best possible way, it was necessary to think in another way regarding the fixing of the windows and doors. It means that the windows were recessed 50 mm from the facade – and thereby further into the insulation so that the solariums are placed as parallel as possible throughout the construction. Furthermore the windows and doors are supplied with fixed parts both externally and internally. In order not to let the cold into the construction, the interior lining is made of an insulated composite material (Hiro). The interior lining gives the possibility of increased insulation behind the fixing.

And the last thing is the clad construction around the windows that normally lies parallel to the facade. It is changed in Home for Life so that the necessaryigor for framing is perpendicular to the facade. With this initiative the linear thermal transmittance for Home for Life is at low as 0.05 W/m²K.

U-values in the construction of the Home for Life

<table>
<thead>
<tr>
<th>Area</th>
<th>U-value W/m²K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>0.10 W/m²K (50 mm insulation)</td>
</tr>
<tr>
<td>Roof</td>
<td>0.07 W/m²K (500 mm insulation)</td>
</tr>
<tr>
<td>Ground level</td>
<td>0.07 W/m²K (500 mm insulation)</td>
</tr>
</tbody>
</table>

Remainder

Mechanical ventilation: Nil.
Natural ventilation: Nil.
Solar heat pump: WindowMaster.
Playhouse: Sonnenkraft.
Indoor blinds: Superwood.

Kongrobes natural slate, Giss Roter collar tiles, VELUX solar panels and solar collectors.
VELFAC Helo®

The active window of the future

With the vision to develop an energy+ window that supplies the buildings with more heat than disappearing and that complies with the strict energy requirements of the future for both new buildings and renovations, VELFAC Innovation Centre has developed VELFAC Helo.

VELFAC Helo is the window concept of the future where unique insulation properties are compatible with strength, durability, surface finish and design. The window contributes positively to the energy balance with regular 2- and 3-layer glass.

VELFAC Helo supports both the low-energy house concept by using under 15 kWh/m² and the active house concept where the house shall produce more energy than it uses.

The frame and sash of the window are made of a revolutionary new material – Helo-Fibre® that consists of PUR (polyurethane) strengthened with thin glass threads. VELFAC Innovation Centrum tested initially more than 200 materials but did not find that the materials were capable of combining the required characteristics. Therefore VELFAC developed Helo-Fibre in conjunction with leading material suppliers in Europe and North America. The material combines for the first time, unique insulation ability with strength, durability and surface finish.

Helo-Fibre is not only particularly suitable for the production of weather resistant low energy windows in high quality, the material is distinguished by the ability to be produced with a uniform beautiful surface. On the basis of its strength the material can be used in a very slim construction and in very large sizes. This gives the possibility to develop unique high-quality windows in a beautiful design with a large unhindered daylight intake.

In 2009/2010 VELFAC Helo will be offered for sale for specially chosen low energy buildings.

VELFAC 200i

In Home for Life VELFAC gives a forecast about active facade windows of the future – VELFAC Helo. But on 1. January 2009 VELFAC introduced two new highly effective energy-packages: VELFAC 200i and VELFAC 400i.

The new VELFAC 200i and VELFAC 400i windows are energy optimized with:

- Thermal break (composite material) between wood and aluminium
- Warm edge
- Reinforced glazing assortment
- Energy glazing bars

In total, the energy-packages provide up to 40% improvement of the energy balance, 15% improvement of the dark U-value (Uw) and 32% improvement of edge-zone temperature on the window.
Energy performance – VELFAC Helo®

- **Solar energy**: Supply of daylight and energy.
- **Natural ventilation**: Automatic control of opening/closing functions. Good indoor climate is ensured.
- **External sun screening**: Solar energy supply is regulated. Up to 88% of solar heat is blocked.
- **Insulation – U-value**: Good insulation qualities. High strength. Basis for energy optimizing.
- **Active window**: Positive supply to energy balance.
- **Internal lining**: Linear thermal transmittance is reduced.
- **Night insulation**: Energy loss in night is reduced. Sunlight in daytime is controlled.
- **Energy data – VELFAC Helo®**
  - **Triple glazing**: U\(_\text{w}\) = 1.23 W/m\(^2\)K with double glazing and argon, U\(_\text{w}\) = 0.89 W/m\(^2\)K with triple glazing and argon.
  - **Net heat gain** = E\(_\text{ref}\) + 18 kWh/m\(^2\)

### Windows in Home for Life

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The following elements in Home for Life are operated automatically but can be manually overridden by remote control:

- Windows on the roof and facade.
- Outside sun screening on the roof and facade.
- Inside blind on the roof.

Additional operations:

- Inside curtain on the facade is operated by pushing a switch.
- Lights operated by pushing a switch and by moving sensors on the ceiling/wall (automatic).
- Heating operated by room sensors on the wall (measures CO₂, humidity and temperature).
- Mechanical ventilation operated by room sensors on the wall (measures CO₂, humidity and temperature).

A part of the operation shall be developed together with the users, such as:

- Time of moving sensors in connection with lighting.
- Standard temperatures in the different rooms.
- Opening/closing times for windows.

Intelligent operation

The second part deals with the integrated control. Intelligent control of the house is necessary to reduce the energy use and increase the comfort together with using the windows as best as possible as sources of light and ventilation openings. Therefore VELFAC has begun cooperation with The Engineering College of Aarhus and the Alexandra Institute with Home for Life as a case. The cooperation has developed into a research project called “Minimum configuration – Home Automation”. The project shall develop and test strategies for the configuration of intelligent operation in the house via user innovation. The purpose of the project is to develop and collect ideas for how complex operations can be both useful and relevant for users. It shall give the residents a complete entry to operation possibilities of light, heat and energy use as well as consumption data.

Measurement of energy use and production

The one part of the test is a measurement programme that will show how much energy is used and produced in the house. In that way conditions, calculations and assumptions can be examined and subsequently validated. This Engineering College of Aarhus is responsible for the measuring.

One test is worth more...

From 1 July 2009 until 30 June 2010 Home for Life will be tested. There will be a regular family of two adults and two children moving in and living their lives in the house.

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