Strawbale house at Birkegårdens Haver

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Content

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Design Brief

The strawbale house is part of the establishment of the Project "Permahaven" in "Birkegårdens Haver", a project inspired by permaculture principles and ethics. The house and garden shall demonstrate sustainability in practice and include various cropping systems that focus on sustainability, biological cycles, biodiversity and conservation.

The strawbale house should appeal to visitors in Birkegårdens Haver and contribute an example and strengthen innovation of ecological building. The project will allow Birkegårdens Haver to go in a more environmentally friendly direction towards the integration of recycling systems with positive impact on the rest of Birkegårdens Haver's organization, activities and public relations.

Project purpose

The project will provide youth and adults practical experience with low-tech, affordable opportunities to make positive environmental changes in own community, through building an environmentally friendly and CO2-saving strawbale house to demonstrate the principles of sustainability.

Target audience

Adults and young people with an interest in practical work with organic straw house building, alternative energy, CO2 saving solutions for buildings, healthy environment and indoor air quality, source separation of waste water and waste as well as the demonstration of sustainable solutions in everyday life, economically, socially, ethically and environmentally.

Expected results

The expected benefits are that a functioning strawbale house will be ready by the end of the project Permahaven with the following characteristics:

• built by participants in two or more courses

• use of predominantly local, nature-friendly and sustainable materials, including thatch

• demonstration facility for the benefit of training in sustainability and self-sufficiency

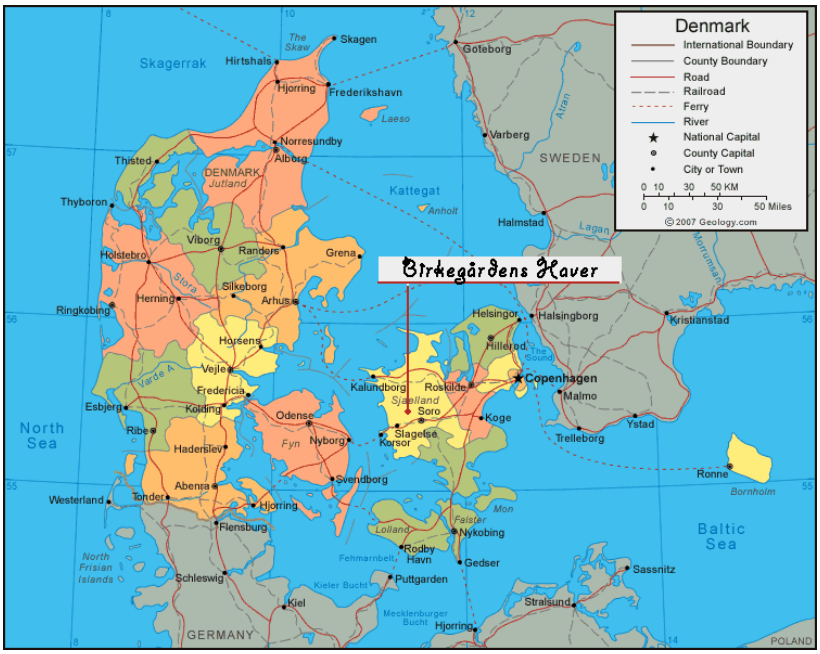
• environmentally-friendly integration of waste, wastewater treatment, and recycling of resources

• energy-saving techniques and elements (solar panels, cold storage, greenhouse and flex oven)

• integration of exterior and interior parts of the house

• involvement of local retailers of building materials.

Background



Birkegårdens Haver (translated the name is Birch Farm Gardens) is today one of West Zealand's biggest tourist attractions with around 40,000 visitors annually. Birkegårdens Haver has evolved from having dairy cows in the 1970s to offer experiences in the form of different types of gardens, activities for children, a café and store in a peripheral region of Denmark north of Slagelse. It is expected that the project "Permahaven" increases

+ the number of visitors, which will help to make the project economically viable and provide the basis for further one or two permanent employees. "Straw house in Permahaven" is part of the project "Permahaven", which started in March 2012 in Birkegårdens Haver.

Birkegårdens Haver is active in Kalundborg County Tourism Association and has strong support from Visit Kalundborg to develop new initiatives and attractions.

Rural Development Fond Northwest Zealand has in collaboration with the Growth Forum and East Denmark Tourism developed a strategy to increase the attraction of tourists to Zealand. This approach involves, among other things, promotion of new “experience attractions” within either culture or within local food - including self-sufficiency. Meanwhile, self-sufficiency, climate and sustainability are taken up for discussion in society generally. The potential for use of resources and the interest to make a contribution to sustainable solutions gave rise to preparing a project about self-sufficiency and resource utilization, which has been supported by the local action group, Development Nordvestsjælland.

The design process

The family at Birkegårdens Haver hired me for 6 months to build the strawbale house that was part of the project “Permahaven”. The “Permahaven” project was created by a permaculturalist that I knew through the permaculture association. She was to set up a 2700 m2 permaculture garden. She showed me the project outline for project “Permahaven” and recommended me to the family. They employed me firstly to work as an assistant to the other permaculturalist, but after a short time, they gave me the responsibility for building the strawbale house.

Roles and responsibilities

The coordinator

My role as the coordinator was:

- to design the house in cooperation with the family and the builder,
- to make the design and the drawings of the house,
- to decide on use of materials,
- to make sure the design was in accordance with permaculture ethics and principles,
- to be in contact with the County (Kalundborg Kommune) and get the planning permission through,

- to get the approval of a building engineer on the safety of the construction,
- to get the approval for the insulation values of the house including the values of walls, doors, roof, windows and floor from another building engineer,
- to get approval from the chimney sweeper on the flex oven,
- to organise the workshops,
- to promote the workshops and handle participants,
- to get all the materials needed – clay, straw bales, mussel shells, PE membrane, geotextile, green round wood, rafters, OSB panels, floor boards, stones and bricks, thatch, concrete pipes for the chimney, drainage pipes, screws, nails etc etc. Tools.
- to get in contact with the local entrepreneurs and craftspeople for supply of materials, paper wool,
- to find all the windows and doors second hand,
- to be the runner, while the workshops lasted,
- to build within the budget.

The builder

The builder's role was:

- to recommend design ideas and materials to the coordinator,
- to determine if the design was feasible in 8 day + 3 day workshops
- to be the leader of the workshops,
- to bring special tools needed for the construction.

The family

The family's role was:

- to provide administrative services,
- to promote the project,
- to provide wishes for construction and approval of designs,
- to provide support for practical tasks, tools and materials,

Design tools used

Project management

The building project followed a regular project management model, including 1) study of the **design brief** and background documents; 2) **client interview** and **research** on different options for construction and materials; 3) **analysis** of the different options and ideas according to **design criteria** and **permaculture principles**; 4) **organisation** of workshops; 5) i**mplementation** of the design and building the building; 6) **follow up** on tasks; 7) **monitoring** of functionality and **evaluation** of design; 8) **celebration** of the finished building.

Client interview

The design brief was clear and the task was to build a house within the frame that was set out in the project description. The first task I took on was to do client interviews with the different members of the family, see the appendix on "Client Interview" to know what the family wanted. Their ideas on uses of the house were quite different from each other. My task was to find the best solutions and compromises between the family's ideas and wishes and the builder's recommendations and abilities. The themes that the building should include were decided upon in dialogue between me, the family and the builder during the first two months of the project. The themes are described in the sections below:

- Using permaculture ethics and principles
- Demonstration
- Knowledge and skill sharing
- Society
- Health
- Certification
- Public relations
- Training

Using permaculture ethics and principles

Ethics

The building design starts from the permaculture ethics.

Earth care in this case means:

- producing no waste through the construction of the building,
- storing carbon in the building through the strawbales and wood used in construction,
- reducing need for energy used for heating through passive solar design and rocket mass heater design,
- purifying the air from the rocket mass heater with a smoke washer,
- creating an envelope around the core of the house consisting of a green house on the south side and cold store on the north side to reduce energy consumption
- using a compost toilet system

People care in this case means:

- creating a healthy indoor climate with clay and other natural materials
- creating a teaching space for people to gather and enjoy
- reducing pollution from materials and smoke

Fair share in this case means:

- sharing of knowledge and skills of natural building and strawbale houses and mass rocket heater through workshops
- sharing innovative designs on cultivated sewerage treatment system in the greenhouse, rocket mass heater and smoke washer
- media coverage of the building construction

Principles

The permaculture principles has been applied in practice in the construction. The house construction combines traditional methods with new technology and experiment with permaculture principles in construction, such as using natural materials, optimizing natural functions and optimal placement of elements relative to each other.

Most important principles in function are:

Creating small-scale intensive systems. The problem is the solution

The project “Permahaven” is about demonstrating how to reduce the climate and environmental impact of human activities, including the settlements. Therefore, testing new opportunities for energy and resource-saving approaches such as reducing waste, reducing energy consumption for heating and cooling and recycling of "waste" have the goal of exploring modern methods to reduce our environmental footprint and improve the recycling of nutrients. The feedback loops are much reduced, e.g. for waste water the water is treated on site instead of becoming part of the municipal sewerage treatment system. This fosters a greater responsibility in relation to what is put into the waste water and how it is treated. It also transforms a problem to nutrient availability solution.

Cycling energy, nutrients and resources. Produce no waste

The application of a permaculture design means that all parts of the system work in feedback loops and the excess ("waste") in a system must be input into another system. For example, many resources in the form of used building materials can have new life with creative thought. It also means that all elements of the house should have several features that help to increase the stability of e.g. food, energy and water supply. At the same time it integrates designs of self-sufficiency in energy and food and cycling of nutrients between the household and self-sufficiency garden.

As an example, the house has a cultivated sewerage treatment system built into the greenhouse which recycles nutrients from waste water from kitchen and toilet into the edible plants, like tomatoes and cucumber.

Each element performs many functions

The house as an element is multifunctional in its design. It includes a teaching space, kitchen, mass rocket heater, upstairs room for multiple functions (storage, bedroom, and office), compost toilet, cold storage and greenhouse with cultivated sewerage treatment system.

Each important function is supported by many elements

As an example, energy for heating is one of the most important functions in the house. The passive solar design uses the greenhouse effect and big doors on the south side to increase the greenhouse effect. It stores solar heating in its mass in walls and floor. The rocket mass heater is another element that produces heat.

Use and value renewable resources and services

Materials used for the house should be obtained as locally as possible. For example, the strawbales will be harvested from the neighbour’s field; the round wood timber will be cut from a forest 3 km away; and the clay comes from digging out the foundation and from the nearest quarry 8 km away. Local entrepreneurs are hereby involved in the project both economically and with their skills and knowledge.

In the long term, it is also advantageous to use materials, tools and methods that are easily available locally, so that the maintenance of the building can be done with as little energy load as possible. Finally, the building can be disposed of with very little negative impact on the environment, as it mostly consists of biodegradable materials and thus can composted.

Catch and store energy

The building was designed to use passive solar heating to increase catching energy. A greenhouse on the south side increase the greenhouse effect and heavy clay walls and brick floor increases the storage of heat in their materials.

On the north is a cold store, insulated under the roof but built with direct contact with the soil underneath and a cold air pipe to keep an even temperature all year round. The cold store helps in catching and storing products from the garden.

Throughout the project Birkegårdens Haver would like to contribute to widen the knowledge base and experience with sustainable materials.

The construction ideas and analysis

I made a first design to attempt to put all the different functions into the house within the budget. I needed to read a lot to start to understand how to build strawbale buildings. My main sources of knowledge were B. Jones, 2002, "Building with Straw Bales", official building regulation documents in Danish, the internet and different kinds of magazines on building.

This first design was a rectangular building from load-bearing strawbales and with an earthen roof. The compost toilet was in the outer wall with access from inside and outside to allow for easy removal of humanure. There was a small kitchen, a small room for office and a larger room for workshops. The south facing façade was mostly glass and window to allow for passive solar heating. All in all about 45 m2.

The second design had more rounded shapes and a reciprocal roof construction. It included the same functions as the rectangular design. However, I got discouraged to do a round building from experienced builders, because round buildings take longer time to build than square buildings.

Choice of building leader

We agreed that the house should be built in a workshop with Steen Møller, a famous eco-builder from the eco-village Friland, know on national TV. He was chosen because of his fame in Denmark to get the maximum media coverage. The workshop was set up so that there was going to be enough labour to build the house, to reduce the price of the building, and with the intention of sharing knowledge and skills about eco-building.

After the decision was made to engage Steen Møller, I travelled to Friland to meet him and talk about different options for the house. He had a few different ideas for how to construct the house, which I assessed to be within or outside the scope of project "Permhaven", the aesthetics of the family, the budget and the different acquired functionalities of the house.

The different designs were suggested and negotiated between the builder Steen Møller, me and the family at Birkegårdens Haver.

Criteria for construction

Criteria used for deciding what kind of house should be built included:

- The construction should be in accordance with permaculture ethics and principles.
- The materials should all be organic and as local as could be, according to the criteria of ecological construction. For a material to be environmentally friendly and sustainable it is assumed that it:
    - is made from fully or partially renewable resources
    - has low energy consumption in its production
    - contributes to achieve lower energy consumption on a daily basis
    - can be safely disposed without waste problems
    - allows craftsmen and DIY people a good working environment during construction
- The construction should live up to all the health, societal and multi-functionality concerns described below.

- The design should be able to be done within the human resources' capacity present, i.e. myself as designer and coordinator, Steen Møller as builder, the family's daughter as finance and PR responsible and the family in general as giving ideas and approving designs.
- Effort was made to choose methods and materials that would engage local entrepreneurs, suppliers and expertise to reduce transport cost and pollution, and to create local ownership to the project with prolonged effects beyond the lifetime of the project itself. It also created opportunity for local business to promote themselves and or Birkegårdens Haver to receive donations in kind.
- A construction should be chosen that would be easy and safe to build in 8 days of workshop with unskilled participants. This meant that the reciprocal roof was taken out as an option because it would be too dangerous to have people crawling around in several meters height with a chain saw to cut the trusses. It also meant that a timber frame house was not an option, because of the intensive work in making the timber frame. Using cob or stamped earthen walls would take too long time to make. A strawbale load bearing house was the best option because it is the fastest, safest and cheapest kind of house that can be built.
- The load bearing strawbale house is the speciality of builder Steen Møller and he has built many load bearing straw bale buildings. This is part of his concept. He was comfortable about this model of house and could easily plan the 8 day workshop based on this.
- Roof: the option of an earthen roof was on the table, but the family liked the idea of having space on the first floor, so a house with high rise roof was chosen. This also enabled a very simple and fast construction with trusses in an A frame as seen on the photo below.
- The size of the strawbales was determined by the baling machine on the farm.
- Green round wood for trusses was the cheapest, fastest and most organic solution possible.
- An 8 day workshop was chosen because from experience, participants and builder start to have less energy after 8 days.
- 8 days usually balances the expenses for builder, food and accommodation with income from around 16 participants, which is an optimal number of people for the builder to manage during the workshop. More people are good for the budget, less people not sustainable.

The decision making around the house design took about a month of discussion, clearing with the family and the builder. We went through different house designs, as described above. Finally, a photo of a house, much like the one built, was found on the internet. The visual image was decisive in getting consensus in the family about the solution chosen. Once decided, the details of the load bearing strawbale house could be worked out. We could also agree to and formulate a set of functions important to the house and fitting with project "Permahaven".

Generally, decisions were made in a process of me developing the house design bit by bit. I would check with the literature on ecological construction on how to do it. Then I would ask the builder if the method and material was appropriate. He would give feedback from his experience. The method and material was then presented to the family who gave their input. Another round of research and checking with the builder would be necessary if the family didn't agree.

Demonstration

The intention was that the strawbale house was to demonstrate the principles of sustainability and was part of the project Permahaven, a demonstration and dissemination project. There would eventually be many activities and different ways of involving Birkegårdens Haver's visitors and other participants in spreading the knowledge of various techniques and materials within sustainable building, permaculture and self-sufficiency. The network among people interested in building and permaculture would also be strengthened.

Knowledge and skill sharing

Sustainability in practice is demonstrated partly through building courses where adults and young people can test

methods and teaching techniques and materials to know. I planned two courses to fulfil this target. The first course was the design of the strawbale house shell with foundation, walls, rafters and gables. The second was the construction of masonry rocket stove, smoke washer and chimney.

Transfer of knowledge about ecological building through courses ensures understanding of the environmental impact of different types of construction, while participants gain practical experience in dealing with the environmentally friendly building materials. The courses also had a social dimension, for instance through networking, that together with the project's demonstration value increases awareness of sustainable construction.

An important aspect that I incorporated in the design was the use of the strawbale house to promote knowledge sharing in the long term, as it was intended from the design brief that the house was used for courses and lectures about permaculture, sustainability, self-sufficiency, ecological building and more. The strawbale house would serve as the focal point for activities in Permahaven which would accommodate practical work and workshops. Work in Permahaven was then enabled to continue during the winter months and extend Birkegårdens Haver's opening hours to become a year-round attraction. Therefore a heating source was necessary in the house.

Steen Møller, one of the most experienced builders and workshop leaders, has since 1996 experimented with the use of natural materials in construction. Being the most known ecological builder in Denmark, he was hired as a consultant to build the house in a couple of workshops. Materials such as straw, clay, shells, wood and stone are the main elements of his design. Steen Møller is the initiator and known from DR broadcasts on "Friland eco-village" for its innovative and experimental buildings and thoughts about society. Friland eco-village is a cooperative which demonstrates the building of affordable and environmentally friendly housing without debt. Steen Møller's specialty is to hold workshops and provide the participants with an understanding of the process of building a house from foundation to roof.

Society

In the economic situation that currently characterizes our society, the possibility of better use of already available resources is desirable for many people. It can also act as a major challenge to be environmentally responsible; reducing one's ecological footprint and getting the economic ends to meet. I incorporated these three challenges in the design of the ecological building, with its relatively inexpensive, locally produced and CO2-saving materials increasing the chances of freedom from debt and mortgage and reducing the climatic impact. This is especially for young people who are about to establish themselves.

In the long term, a strawbale house reduces CO2 emissions and impact on the environment due to its sustainable features. The house is built to include passive solar and photovoltaic energy, heating with wood, integrated waste management and composting human manure. This means that the strawbale house offers solutions for peripheral areas where service functions such as drainage is less common and electricity can advantageously be produced locally. The strawbale house is therefore an example of comfortable habitation with very low impact, affordable economy and greater independence of services and creative individuality.

The strawbale house provides practical experience in getting to know the materials and techniques developed. It was also be considered, where appropriate, to get inspiration from the traditional crafts and Raadvad centre, which is an organisation specialising in the traditional craft related to building and architecture. They had good advice on how to restore and energy optimise second hand and old single glazing windows.

Health

Natural materials are being used in the strawbale house and were chosen because: they provide a better indoor climate; the construction process is pleasant and safe to work with; and they can be easily removed without affecting the environment.

Clay plaster on the strawbales on the inner and outer walls and the floor, provides a vapour permeable and breathable house that can regulate the humidity indoors and carry excess moisture through the walls. If clay is used there is no need for a vapour barrier with its disadvantages such as stuffiness and humidity. The use of natural materials is also said to be generally better for health than many of the artificial and chemical substances added to construction products on the market today.

Straw walls greatly reduce noise levels inside the house because of the thickness of the bales. The lower noise level, in combination with the proximity to nature and garden with functional ecosystems are expected to counteract stress, and to promote peace, openness and balance.

The strawbale house in Permahaven was intended to help to promote a healthier lifestyle and access to sustainable choices.

Certification

There is not yet a certification for environmentally friendly and sustainable building materials in Denmark, although it would be highly relevant in this time when climate issues are very disturbing. Eco-friendly and sustainable building materials cost less energy and CO2 to produce. In the journal of the Organisation for Renewable Energy, OVE, you can read that CO2 emissions are four times smaller from the insulation with paper wool instead of rock wool, and the total CO2 emissions are 12 times less by installing passive house windows in wood rather than windows in aluminium with energy glass.

Public relations

The garden is open to the public, while the first building workshop is conducted so that interested parties can gain insight into building an ecologically friendly house.

Training

Dissemination of practice around the strawbale house building and DIY occurs in two or more courses involving trainees and training of builders. First course in the construction of the shell is scheduled for week 37, 2012, with 20 participants. Construction of a flex oven and chimney are scheduled for November with 8 participants. Thereafter, several workshops for example in plastering walls with traditional materials, coating the floor with linseed oil and fibre, installation of a hand-built staircase and other woodwork with professional craftsmen.

Media

The strawbale house was the subject of press attention as project Permahaven already has been in the printed media several times, including articles in the newspaper Zealand Business, the business magazine Kalundborg, and the weekly trade journal Soil & Knowledge. TV and selected local newspapers will be invited to follow the construction process.

On www.birkegaardens-haver.dk the project is documented along with text and photos and annually 100,000 leaflets about Birkegårdens Haver are distributed.


Photos: Left: Eco-builder Steen Møller. Right: Owner Merry Sørensen and an employee bringing coffee and snacks for the workshop participants.

Designing the strawbale house

Loadbearing strawbale

Based on the ideas put forward by the family, the builder and me, it was decided to construct a load bearing strawbale house because it is:

Sustainable: Straw is an annually renewable natural product, formed by photosynthesis, fuelled by the sun. It is low in its carbon footprint; actually it has a negative carbon footprint, storing carbon in the building. Strawbale buildings can cause a net decrease in greenhouse gas emissions.

Highly insulating: Straw provides insulation at an affordable cost. In walls over 45 cm thick the U-value is 0.13W/m2K, 2-3 times lower than contemporary materials (B. Jones, 2002, "Building with Straw Bales") when used with a clay or lime plaster.

Inexpensive: Strawbales are very cheap as building materials and locally sourced. Savings are high in the long-term on fuel reductions owing to the high level of insulation and thermal mass.

Fast: Strawbales are big building blocks easily placed and fitted. In comparison, a timber frame construction requires more time and skills. In view of the projected 8 day building workshop, this is a construction method that meets the needs for participant engagement without previous skills.

Acoustically insulating: The thick strawbale walls are highly insulating acoustically.

Tested construction: Load bearing constructions are well tested and the problems in the initial constructions with this type of construction have found their solutions and ensures a structurally sound building.

A healthy living environment: Straw with clay plaster are the building materials of choice for many allergy sufferers because they are natural and harmless, do not give off harmful fumes and are a vapour-permeable materials keeping the inside air fresh.

Empowering: The building process is reported to empower ordinary people, because it is accessible economically and does not require special skills. It enables people to transform their living environment and lives (B. Jones, 2002, "Building with Straw Bales").

The strawbales

The building had 240 cm * 90 cm * 90 cm straw bales in the walls oriented east-west. Smaller bales were used at the gables. The straw bales were harvested on the neighbour's field and therefore the size was fixed. They were from barley straw.

Structure: Green round wood

Photos: Left: The green wood easily debarks when freshly cut because of the sap flow between bark and trunk. Right: The trusses made from round wood in the air.

The structure of the house was designed as an "A" in round wood, because of the simplicity and speed of this kind of construction. The trusses are cut and put together to form "A"s, that rest on top of the strawbale walls. This was a very simple and effective design with 9 trusses made from round wood. Each of the trusses consists of two 8 meters long round woods with a 90 degree angle, with one 6 meter long round wood to hold it together. (See photos).

The red pine green round wood used as trusses and beams are harvested just before the workshop from a friends forest about 3 km away. Round wood is chosen because it is the most environmentally friendly material for building, storing carbon while the building stands and requires no processing prior to use. It looks beautiful and natural. The green roundwood was debarked at the workshop by participants.

Clay plastering of walls

Clay plaster walls were chosen because of their health attributes and fire resistance. It is a local and natural material and pleasant to work with. The clay was partly dug from the ground during excavation for the foundation and mixed with clay from a nearby quarry.

Foundation: Mussel shells

Mussel shells are a resource found in abundance in Denmark. They insulate well, stop capillary suction from the ground and drain freely in case of excess water, so they are well suited for foundations under strawbale walls. Sand and stones are traditionally used in old buildings, but mussel shells insulate better and stop capillary suction better.

Roof

The strawbale house should have been equipped with a thatched roof in 2012 or when funds were sufficient. The thatched roof was part of the conditions for the rural zone permit and would make the strawbale house into an attractive element in Birkegårdens Haver and enhance the aesthetic experience, which could help the general public better identify with ecological construction. An earthen roof was taken into consideration, but deciding to have a high rise on the trusses, made it impossible to make an earthen roof because of the inclination.

On the south side was projected a curving line of solar panels for electricity above the glass roof of the greenhouse. “Huntonit” plates were put as roof for the protection of the house until the permanent roof is laid. Huntonit plates are a natural product from wood and linseed oil, which fulfil the criteria of a clean indoor environment. Huntonit was used as an under-roof and is rainwater proof, water repelling, open to diffusion of air and moisture and prevents condensation.

Floor

On the ground floor, burned clay bricks were used, because they were in abundance in different colours on the farm. The ceiling of the main room was made with Douglas pine floorboards from a nearby artisan sawmill because after talking to him a few times, he wanted to donate the floorboards to the project.

Inside on the loft

The inside cladding is from OSB plates (smartply) in double layer, a fairly natural wood product. Clay plastering was considered and abandoned because it could not be done in the workshop and would then be too time consuming for the family to do. Gypsum plates was another option, but less organic than the OSB plates.

For insulation under the roof, loose paper wool was chosen. It was blown in once the inside cladding was completed. Wood fiber would arguably be the best and longest lasting material available in Denmark, but also more expensive. Both have borax salt as fire retardant, a salt which is somewhat toxic, but a natural material. Paper wool is getting quite common in Denmark and a local workman would be able to do it. This was a compromise between the easiest, the most affordable and most organic material on the market for insulation. Of course, seaweed or sheeps wool could have been used, but this solution was too expensive or labout intensive. The blowing in of the paper wool is a very easy and affordable method when you don’t need to do everything yourself.

The walls should be painted with casein paint, a white paint made from equal parts of lime (binding), kaolin clay (white

filler) and fromage frais. Fromage frais is a milk product with high content of the protein casein, which acts like a glue and low contents of fat that would reduce the ability to stay on the wall. This is the most organic and cheap solution available for indoor painting. However, it is somewhat time consuming to apply because it needs to be stirred all the time to keep the solid particles in suspension. Clay paint would also be a good solution and some nice organic clay paints are available in Denmark, produced in Germany. They are more expensive, but very healthy feeling and covers almost 100 % first time.

Another solution was chosen in the end which was second hand plastic paint. The plastic paint had been partly dry and made strange flakes on the walls. Of course it also blocked the permeability through the walls and gave the room a plastic feel to it.

Windows and doors

All windows and doors were second hand in good quality. Second hand was chosen to reduce pollution from producing new windows and because of the budget. The glasses should over time be changed for low-energy glass to get a better U value and less heat loss. This will be done by local artisans inspired by the "Raadvad centre", which is an organisation for the promotion of traditional crafts related to traditional building and architecture.

The number of windows and doors were chosen to live up to the Danish building standards of a 2015 standard passive house. This meant a limited amount of windows on the northern side and big windows on the southern side.

A double door leading down steps on one side to the east was nice to have because of the openness into the house. On the western side, a broad door was chosen to allow for wheelchair access on level with the outside terrain.

The Cold store

In a permaculture house, storage of food is essential and important to self-sufficiency. An earth cellar was originally planned to take care of this need. However, with the construction of the house with the A frame trusses, the opportunity was there to create a cold storage room on the northern side of the house. This was also a cheaper option because it was going to be built anyway.

The cold store on the north facing side has the thatched roof coming down to the ground for insulation. The ground is not insulated, allowing earth temperature to cool down the cold store in summer and keep it frost free in winter. A 20 cm diameter drainpipe is put down under the mussel shell foundation to keep air flowing through a relatively stable temperature from one side of the house and into the cold store. This solution increases the usability of the cold store.

Heating - The flex oven

Different options source for heating the house was discussed, but only one solution was realistic within the criteria and budget – the flex oven or rocket mass heater. A small wood burner would also be an option. However, the solution that Steen Møller suggested implied not having to build a chimney through the roof, which would significantly reduce both cost and time spent on building the house. The flex oven was also an innovative experiment that could attract the attention of journalists and other eco-builders and people within permaculture and likeminded.

Heating was therefore chosen to be done via a flex oven (a modified kind of rocket mass burner), which is a very simple furnace that can be used for cooking, heating and water heating. It uses less wood than traditional open fire, can burn small pieces of wood, produces less pollution and can easily be constructed from cheap materials.

A flex oven optimizes the efficient combustion of fuel with a high temperature by ensuring that there is a good air supply to the fire, controlled use of fuel and efficient use of heat.

The flex oven is a new development of the classical design. The main body of the flex oven is made from normally burned clay bricks and cob. The fire chamber is insulated by vermiculite to increase temperature fast and secure a high

temperature even at the beginning of the fire. The metal pipe is leading up towards a marble plate with an iron ring inset for cooking. The smoke is then channelled down into the floor and through pipes under the floor to give heating from beneath and mass storage of heat. The smoke comes out through a pipe at ground level, with a small fan to draw the draft through the pipes.

Now comes the interesting part: Before the smoke is led out into the open at ground level, it is run through a washing device to decrease the amount of particles released. The pipe goes through a hole in a bin which is filled in side with leca-nuts, a product made from burned, puffed clay balls the size of a hazelnut. The leca-nuts have enormous pore space and are very porous, thus increasing the surface through which the smoke needs to travel, but without becoming compact. Water, sent through a little pump from the bottom of the bin, is sprinkled over the leca-nuts, kept together in potato sacks, and the smoke. The water will catch the particles of smoke and ash. Ash is an alkaline substance while CO2 gasses in the smoke are acid. Through mixing of ash filled water and acidic smoke it is hoped that a reaction will be created to make the substances neutral, leaving mineral compounds similar to those found in the wood. However, this needs to be tested.

Firing the flex oven with the sprinkler watering the smoke, let out air that is barely noticeable as smoke.

I produced a video with Steen Møller to show how the flex oven with smoke cleaning system works:
https://www.youtube.com/watch?v=Hfw2Ec1gKYw

Photovoltaic

At the time of designing the house, it was very profitable to install solar panels, because of the returns on the electricity bill. Solar panels would allow making money and the family liked this aspect. This profitable practice was however changed by the government a year after the design of the house to a less favourable scheme.

In any case, solar panels on the building's south side would give a contribution to the electricity consumption of the house and be a renewable source of energy. The solar panels would be installed as an extension of the greenhouse and be an installation of 2,000 kW, with a production of about 1800 kWh per year. This is an investment which would eventually donate to the straw house and Permahavens operating budget. The solar panels would provide power to operate the teaching materials, as well as lights, computers, and water and smoke pump. The solar cells can be connected to Birkegårdens Haver's other power system.

Greenhouse – multifunctional cultivated evaporation plant


Photo left: Channels of clay soil are seperated from the mussel shells with geotextile underneath the greenhouse, September 2012. Photo right: the finished greenhouse with cultivated evaporation plant, June 2014.

A greenhouse is a natural part of a permaculture design because of all its functionalities in terms of growing vegetables like tomatoes and cucumbers and other heat requiring plants. It provides space for seed and seedlings and prolongs the growing season. It also provides passive solar heating for the house when built as a lean-to on the southern side of a house. The family was very keen on having a greenhouse and it was easy to make the decision that is should be an integrated part of the house because of the A frame construction. In my opinion it is the perfect permaculture solution because it creates solutions out of problems, harvests a yield, recycles nutrients, works with nature, makes a great effect for little change and produces no waste.

This greenhouse could have even more functions when including a “cultivated evaporation plant” to take care of the grey water and urine. The family liked the idea of not having to dig sewerage from the house and about 100 meters across the gardens to the mains.

The cultivated evaporation plant was designed with inspiration from Steen Møller's innovative greenhouse at Friland, which is a combination of purification of raw sewage and cultivation of edible vegetables in the green house. The wastewater is a resource of water and plant nutrients, if provided for in the correct context.

The greenhouse was designed to be the sewerage treatment system as well as producing plants from the nutrients in the grey water. A membrane was put at the bottom and sides to keep water inside. Three “walls” of clay soil was put in with geotextile around it to keep from mixing with mussel shells. The unbroken mussel shells have big storage capacity for grey water, about 80-90%. The clay walls increase capillary suction from the bottom to the top. A layer of sandy soil was put on top of it all for growing.

Advantages: The greenhouse does not need watering from above, thus hardly any weeds or slugs appear. The plants, i.e. tomatoes and cucumber, are planted on top of the clay walls so that they can get their roots into the nutritious grey water. The system also works with black water. The greenhouse provides both sewerage treatment and production of vegetables, thus making the house off-grid.

Disadvantages: The soil on top or the water storage may become saline because of the added salt to the diet which plants cannot cope with. Residue salt needs to be sucked out some years by the end of the growing season to avoid salt accumulation.

The strawbale house produces gray water from the kitchenette and the sink in the bathroom collected in the greenhouse. From here the water was sucked up through the capillary risers and can be absorbed through plant roots. To eliminate odours, weeds and snails, a layer of non-capillary sandy soil was placed at the top for the plants to grow in. The sewerage system's capacity was about 10 m3 of water, equivalent to 18 litres of water per day per year with an evaporation rate of 0.5 m3 per square meter of surface. Since the strawbale house was only going to be used for teaching and had an emphasis on reducing water use, this was considered to be sufficient. There was installed an overflow channel in case of overuse.

With this installation the experience base for the integration of water management in greenhouses increases and it was made available for trials and tests towards a future approval of this type of plant. If the plant was not approved or not used for grey water, it would still act as a sub-irrigation system with capillary ascent, but with rain water.

I produced a video with Steen Møller to show how the greenhouse/sewerage treatment system was constructed: https://www.youtube.com/watch?v=6IX-wZI6gPA

Compost Toilet

Some discussion around the compost toilet was taking place between the family and me. The idea here was to show how human manure becomes a resource rather than a costly problem.

If a normal toilet was installed it would mean having to connect it to the main sewerage channel with all the costs involved. It could be connected to the greenhouse cultivated sewerage treatment system. However, the planners at County council were not happy about this idea. The most organic and available option was therefore a compost toilet with biodegradable plastic bags that could be composted – or disposed off in the normal sewerage system. The compost toilet could not be too "homemade" because of the paying visitors at Birkegårdens Haver. Therefore, a nice looking compost toilet that separates urine and faeces could be installed. The urine could be collected in the greenhouse sub-irrigation storage system and through capillary ascent be available to the plants grown in the greenhouse.

The choice of compost toilet initially fell on an approved Swedish toilet. The construction of a woodland garden and fruit trees in Permahaven would be where the compost could be useful. Faeces mixed with carbonaceous material like sawdust or straw and composted two years is used as fertilizer for trees.

Cross section of the straw bale house

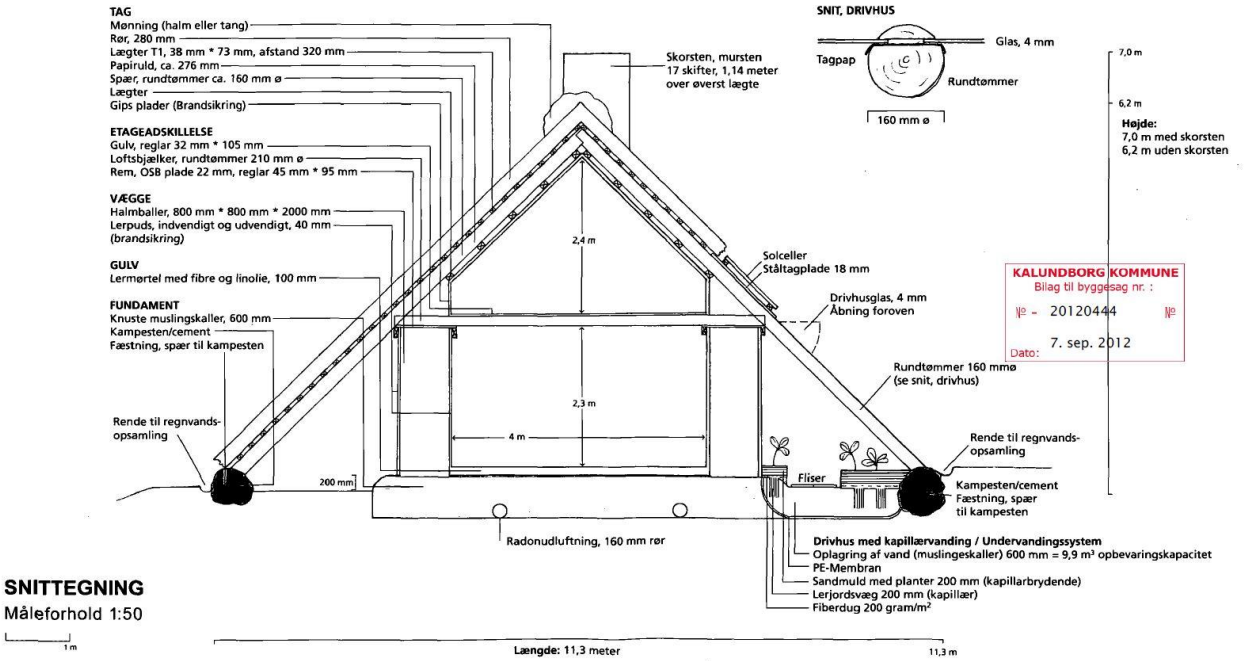


Illustration: Cross section of the house. North is to the left and south to the right. Explanation of the cross section beneath. Drawings are made by me, first with pencil. They were later scanned and drawn in Adobe InDesign.

The walls are made from strawbales, 900 mm, clad with clay plaster inside and outside, 40 mm.

The roof is made from straw, 280 mm. Underneath is Huntonit plates with at least 50 mm to the straw for air circulation. The trusses are from round wood, with laths across for gypsum plates in two layers to obtain fire resistance. Insulation is paper wool between the trusses. Clay plaster instead of gypsum plates would be an ideal material, but also difficult, messy and time consuming. Casein paint inside.

The floor between ground floor and first floor is made from douglas fir floorboards resting on round wood.

The walls on the ground floor are made from strawbales with clay plaster, 40 mm.

The loadbearing strawbales sit on a foundation of compacted mussel shells, about 1 meter deep. The mussel shells prevent capillary suction and insulates the floor.

The floor is from clay with fibres and linseed oil.

The trusses are fastened with bolts to big stones to keep them off the ground. The thatched roof reaches down to about 50 cm above ground level on the northern side of the house.

There is a chimney, 17 shifts above the top lath.

On the southern side of the house is thatch on the top part, then photovoltaic panels on top of steel plates. The greenhouse starts where the strawbale wall corner is. There are two window for air circulation. The greenhouse glass rests upon the green wood trusses.

There is drainage on either side of the house to take excess rainwater. It drains into a pond which serves both as water storage for the garden and habitat for animals and plants.

The height of the house is about 6.2 meter to the ridge.

The greenhouse houses a waste water treatment system. Please watch this movie for more information: https://www.youtube.com/edit?o=U&video_id=6IX-wZI6gPA

Schedule

• In April 2012, the Rural Development Funds were allocated for the project Permahaven through Development Nordvestsjælland.

• In May 2012, the project coordinator Cathrine Dolleris started working with builder Steen Møller, known from the broadcasts of "Friland" on the TV channel DR2 and Birkegårdens Haver about the design of the strawbale house.

• Exploring opportunities for local suppliers of sustainable building materials May – September 2012.

• Approval of the rural zone permit and exemption for materials from Kalundborg Municipality expected given 18. July 2012.

• Building permit given before 6. September 2012

• 7th-16th September a course held for up to 20 participants in the straw house building with greenhouse, cold storage and cultivated evaporation plant for sewage.

• In October and November 2012, thatching of the roof with straw and installation of solar panels.

• In November a workshop in building the flex oven.

• The house is fitted with interior decoration and used for lectures and courses during the winter 2012, as well as for the storage of crops and tools.

• In the spring 2013 the strawbale house is used for courses and lectures on permaculture, self-sufficiency and ecological construction, practical workshops in the garden and the house, and more.

• March 2014 is the ending of Project Permahaven and daily management will be transferred to Birkegårdens Haver with the continuation of activities and dissemination knowledge about sustainability and ecological construction.

Economy

Budget for the project

Activities	DKK
Project strawbale house (5 months of 16.000 DKK/month Wage) for project coordinator	80,000
Construction of the raw straw house	
Materials, consulting engineers, plumbing, electricity, rent tools	245.350
Consulting engineers (statics, heat calculations) 15.000	
Rental tool (backhoe, wheel loaders, compressors, etc.) 11,000	
Craftsmen for plumbing and electricity 20,000	
Builder	32,000
Workshop, a minimum of 16 participants of 3750 DKK each	-60.000
Organic food and lodging for workshop participants	30,000
Construction of the chimney, clay plaster / organic paint finish	
Masonry stove builder to finalise flex oven, clay plaster specialist	24.000
Workshops, a minimum of 8 participants at 4000 DKK each	-30.400
Organic food and lodging for workshop participants	20,000
Photovoltaic incl. mounting	40,000
Thatched roof, materials and thatching	59.750
Inventory (educational equipment, projector, kitchenette, tables, chairs, etc.)	25,000
Total:	465.700

A total budget of 465.700 DKK (50.000 GBP).

Operating budget for the project after completion

Activities	**DKK**
Maintenance per year	15,000
Salary for maintenance	11,000
Solar Power, approximately 1800 kWh / year (1.77 kr. KWh April 2012)	-3,186
Lectures, courses, etc.	-5,000
Advertising	4,000
Admission revenue (200 guests of 75 DKK)	-15,000
Total:	**6,814**

The building workshops

A workshop with 20 participants was planned for September 2012 with Steen Møller as the builder. The raw house was built including strawbale walls, trusses, huntonit under roof, floors, a chimney under the floor and the waste water treatment system. However, only 14 people came, which was not so good for the economics of the workshop.

The participants were accommodated in a “strawbale hotel” set up for the occasion in one of the barns on the farm. Some participants slept in their cars or in tents.

A second workshop was planned for November to build the flex oven with 8 participants and Steen Møller as the workshop leader.

Images say more than many words, so following are photos from the workshops describing the work done.


Photo left: The blue tube is 18 meters long and perforated. It will suck air under the house, cool it down and thereby cool down the cold room. Right: Mussel shells as foundation with the blue tune underneath. The pipe is the chimney that will be under the floor of the finished house. The pipe is made of seven 30 cm concrete tubes normally used for sewerage and is in total 14 meters long.


Photos: Left: The sewerage system under construction. The reservoir has a layer of geotextile towards the ground to

protect the plastic foil. On the inside, another layer of geotextile was placed to protect the plastic foil from the sharp mussel shells. Mussel shells in a layer of about 20 cm is placed in the bottom of the reservoir. Right: On top of the 20 cm layer of mussel shells, the clay "walls" are constructed. Geotextile is keeps the clay and the mussel shells from getting mixed together. The plants in the green house are eventually planted on top of the clays walls that have good capillary suction to provide the plants with the nutritious waste water.


Photos: Left: The waste water treatment system is covered with a layer of 20 cm of sandy soil which has limited capillary suction so that the water does not come to the surface. This layer prevents odours from the waste water and keeps the soil dry and free of slugs, mold and unwanted plants. On the far side, the mussel shell foundation has been put in place. The mussel shells are crushed to give better stability. Right: The sewerage system is finalised and the first strawbale is placed.


Photos: Left: The first strawbales on the south side are in place and frames for the two doors to the greenhouse are placed. Right: The strawbales are lifted and pushed into their right place with a Bobcat. They each way about 250 kilos.

Photos: Learning how to split a strawbale in two halves: A big needle, at least the length of the strawbale, is threaded with string and put through the strawbale. This is done in two or three places, depending on the size of the strawbale. The strings are tied around the two halves of the strawbale and when tight and secure, the old strings are cut. Then it requires a bit of work to split the bale in two.

Photo: Left: A wall top was built and put on top of each of the walls to secure the strawbales, protect them from the coming rain and to have an even surface for distrusting the weight of the trusses. Right: Placement of the strawbales. Two doors will be fitted in on the south side of the house. The strawbales, wall top and door frames are held tight together with plastic strips that can be tightened as the weight increases on the strawbales and compresses them.


Photos: Left: The green round wood is being debarked. Right: On side of the beam holding the two trusses in place is cut flat with a chainsaw and a device that holds it at a certain level to make the cut straight. The cut side will turn upwards as support for the floor planks on the first floor.


Photo: Left: The trusses are constructed on the grass. Iron rods are fastened in the soil to make the shape right for all the 9 trusses. Right. The first of the trusses is lifted into place with a crane.


Photo: Left: Getting the first of the trusses secured by the rafter was an intense moment, because it could tip. Right: All the trusses were placed and secured with rafters so that they would not tip.


Photos: Left: It starts to feel like a house. Right: A topping-out ceremony with a traditional wreath on top of the house fas held on day 4 of the workshop.


Photos: Left: The owner observes the work being done. Right. Rafters and huntonite roofing is put on the trusses.

Photos: Left. Each of the trusses is fastened onto a big stone with a big bolt.


Photos: Left: Steen Møller talks about using clay plaster. A clay content of 15-20 percent is adequate for plastering. If it is more it will crack, if it is less is will crumble. Right: The quality of the wet plaster can be checked. By putting clay, as shown on the photo, and left to dry, it will show at what thickness the plaster cracks, if at all.


Photos: Left: Another sample will show how much the clay plaster shrinks. Note the line on the wood. Right: Samples with different clay content.


Photos: Left: The first layer of clay plaster being applied with compressed air and a kind of showel that sprays the plaster well into the straw. Right: The gap between trusses and roof is filled with straw for insulation.

Photos: Left. The sewerage pipes from the bathroom and the kitchen are put into place in the mussel shell foundation. Right: An orange decanter's well settles bigger particles from kitchen and bathroom before entering the sewerage treatment system underneath the greenhouse.

Photo left: The model and the real house. Photo right: The building team.

Photo: Left: The gables are closed with strawbales. Right: The gable roof has a large overhang to protect the upper wall from rain.


Photos: Left: The floor is made from burned bricks found in abundance on the farm. Right: The brick floor allows for immediate use, which was practical while building.


Photo left: Construction of the innovative flex oven. Photo right: The finished flex oven with the chimney under the floor.


Photo left: The smoke filtration system, version 1. Smoke comes in from the big pipe at the bottom of the photo, filters through the orange bags filled with leca nuts and is sucked out through the smaller hole.

Photo right: Smoke filtering version 2. The smoke is forced through the yellow bags to the bottom of the blue container first, then comes up through the orange bags afterwards. Water is sprinkled over the bags, which contain leca nuts. The pipe measures water level.

Photo: The house in evening sun while the roof is under construction.

The finished strawbale house

The project officially closed and funding ended in June 2014. The house and garden was taken over by the normal operation of Birkegårdens Haver at that point.

Photo: The finished house June 2014 with parts of the mandala garden in front that I designed for herbs and "edimentals".


Photo left: the eastern side of the house with greenhouse towards the south. Walls have lime plaster. The original plan was to cover the lower part of the wall with wood for protection from the rain. Photo right: The wheel and stones are hiding the smoke washer system.


Photo left: The cold store now used for tools. Insulation was carefully placed between boards of Siberian larch on top of tiles between the ground and roof. The round lid in the centre of the image is where the underground cold air pipe ends. The floor was made from bricks that were free and abundant at Birkegårdens Haver. Photo right: To give the house a natural finish, I used paving with "pik" stones, a technique often used in earlier days. The family liked the look and use of stones and it was a free and abundant resource.


Photo left: The toilet room. The compost toilet and water was not yet installed. Photo right: The western door with access for wheel chairs. Stones were available freely.


Left: The inauguration of the project "Permahaven" by the mayor of the County, Kalundborg Kommune, cutting the flower string while journalists takes photos. Right: Candela Vargas presenting the garden design while officials listen in front of the house.


Left: Inside the greenhouse, which also functions as sewerage treatment. Right: the rocket mass heater and small kitchen.

Inside the house romantically decorated. The walls are plastered with clay and the roundwood beams are visible in the ceiling.

Because of the relatively small space and for the sake of the interesting example the special staircase was constructed to take up minimal space.


Upstairs, the Douglas fir planks make a beautiful floor and the room is decorated to accommodate visitors. The ceiling is finished with OSB and huntonit plates and paper wool insulation between the plates and the thatched roof.


Photo left: The greenhouse. It was decided to use PE plastic instead of glass, because of the danger of people falling through. Larger stones make a natural finish. Under and to the right of the stones is an underground drainage pibe to a pond. Photo right: The house from the north with one window. The roof has "shoulders" to protect the upper walls from rain. Miscanthus Sinensis was used instead of reed for thatching providing a good result. The ridge of the house is made with mussel shells. Mussel shells were chosen as an untraditional material, reminding us that mussel shells are also at the foundation of the house.

Evaluation

The family owners at Birkegårdens Haver were far from living organically and far from truly understanding the concept of the permaculture garden and the house. However, the family was keen to try something new to attract customers and keen to be more green.

The project "Permahaven" of which the house was a part of, received some support on the terms that this support would be paid back by the completion of the project in May 2014. The support was given only to new materials, contradicting part of the concept behind "Permahaven", which was to recycle and reuse as many materials as possible.

Setting a goal

The interviews with the different stakeholders showed considerable spread of ideas of what the building should be used for:

- A house for demonstration and workshops
- A house for the daughter to live in
- A house for the whole family to live in when the Mayan calendar ended in December 2012 and the following break down of society.
- A house for renting out on a weekly basis to people attracted about the idea of living in a strawbale house.

I had to mediate between these different ideas and also the realistic options connected to the site. The site is a rural area and building permission very difficult to get. The planners at the County agreed that a house could be built, but only as a demonstration house, not for living in. However, this conflicted with the idea of demonstrating a sustainable house for one family. And the budget for the house was also a limiting factor and the economy of Birkegårdens Haver had a bad year. I made sure to involve the family at every step of decision making. Additional funding was applied for and the project carefully described in the application form. The family signed this document, but still had diverging ideas about the use of the house.

I had very long conversation with the builder over the summer, to negotiate the different ideas with a realistic approach to what was practically possible to do in 8 days of a building workshop. The builder was interested in innovative design and testing some new ideas that would fit well with the concept of the demonstration house and would greatly increase the functionality of the different elements of the house, a principle of permaculture. I was also interested in applying these innovative designs. The benefits for the family was a unique design that would be interesting in a media context, something they could promote to attract new customers to Birkegårdens Haver. The concept was also to involve people in the development of these elements and functions in workshops to increase the customers ownership of the project and their willingness to come back to follow the development.

The planners at the County were accommodating to the alternative materials and methods that we used in the strawbale house. However, there was very limited knowledge of the ecological construction, which meant a lot of work for the County employees and for me to find the right documentation to inform them of ecological building materials and their attributes. Also the different ideas of how to use the house meant a long approval process to get to terms. The long process caused some delay in the design, but had in turn led to greater awareness of ecological construction in the County and I am hopeful that it will be easier for the next ecological builders to get their approval.

In total, the negotiations between the different members of the family, the builder, the planners and the funders, were quite difficult. On top of that, the other project employee who took care of the garden and had set up the project from the beginning was quite ill psychologically, and that was another challenge to mediate.

The workshops

The workshop on the building of the house went really well seen from the perspective of what could be achieved with the resources available. However, it was projected that 20 people would pay a workshop fee and work on the house, but only 14 came and some could not pay the full price. 16 people were the break even amount, but the family decided to carry on with the workshop. This created a deficiency in the income from the workshop and also meant that we could not do as much work as was projected for the 8 days. The family had expected a nearly finished house, whereas the builder had pointed out that only the raw house could be built in 8 days.

The second workshop on the flex oven went well, with 6 paying participants instead of 8, but was within the budget. The oven was built, the smoke washing system was constructed and working. The chimney was under the floor for maximum heat transfer to the mass in the house. The washed smoke was led through a pipe under the path outside and ended above the pond dug for rainwater collection.

In this workshop, we managed to do some of the work that was intended for the previous building workshop to catch up with the plan and to satisfy the family. They appreciated the effort, but were still expecting more.

The expectancy of the family was based on the amount of work a normal craftsman could do in the same amount of time with conventional building materials. Building with alternative materials meant that: they were more difficult to come by and so a lot of time was spent on retrieving the materials. For example; Clay is not easy to find in bulk and only one place in reasonable distance could provide clay; The process of clay plastering is more laborious and time consuming than putting up gypsum plates; The round wood was harvested in the forest nearby and very easy to get, but required more work in fitting than going to the DIY shop to get conventional rafters. Also the participants were not all skilled craftspeople, so their efficiency was lower than expected. These facts were pointed out before hand, but since the family had no experience with natural building and under pressure economically, they did not fully have their expectations met.

Another factor was that the employee that was supposed to cook for the workshops called in sick after the first evening and did not come back. The family had to fill the gap, increasing the pressure on them, and then they asked the cafeteria at Birkegårdens Haver to provide the food, making it more expensive than in the budget.

The feedback from participants was generally positive and they said that they had learned more than they expected. A few complained that the strawbales in the “strawbale hotel” were not very comfortable. The food was good, almost too much and too often.

Continued work

The additional funding applied for was not obtained, thus no salary for me or another project coordinator was available, and the project was more or less at a standstill for a year. I would have liked to follow up the functions of the house by writing about them, so that little signs could tell the story of the element or the function. However, this was not prioritised and I was not employed beyond the 6 months. Later I was told that because I was fond of stinging nettles and dandelion, the family was reluctant to employ me again! Also, I had decided to move to Friland to spend time with Steen Møller and the eco-village. I had become very interested in Steen Møller’s philosophy and wanted to experience it firsthand.

The family had several people as interns from the unemployment office to work on the project. However, the knowledge of how the house functioned was not available. I helped them as much as I could by answering all their questions thoroughly on telephone or email.

Nearing the deadline of the project in May 2014 and with a view to get the financial support released later in the year, the family was interested in finalising the house and garden. They found a gardener with good ecological gardening skills and interested in permaculture. She later did a PDC to understand permaculture better. Another permaculturist was also employed part time in the garden.

In April 2014, I was employed for 9 days to finish the house. I gathered as many people as was able to work for free or with a small salary, to do as much work as possible on the house to finish it. The house had been plastered nicely with clay plaster on the inside and lime plaster on the outside. It had gotten a beautiful thatched roof, but pressure-treated wood had been used. The family didn’t notice this, but I and the two ecological builders I had gathered saw it instantly. The family responded by painting it over. The greenhouse was not yet covered with glass. The gables on the ground floor were made during the 9 days, i.e. the doors and frames to the cold store and toilet. The insulation under the

north side was done and a wall to separate the cold store from the toilet. Steps, a ramp for wheelchairs and paving outside were done.

It was not possible to finalise the house in 9 days, so they hired professional craftspeople to do the last work before the inauguration in June 2014.

Changes in the house construction and functionality of elements

Due to the lack of understanding of the different functions of the ecological building materials and elements, changes to the original design were done. If the family had employed a person with skills within eco-building some of these changes could have been avoided. Some decisions were simply just changed because of aesthetics or lack of awareness.

A done differently would have been to get more time for making signs to describe the different functions. However, I was only employed until the workshops and did not have time to transfer the knowledge in a more efficient way. To be honest, I'm not sure that it would have mattered, because the concepts were anyway poorly understood because of a lack of willingness and openness from some of the family members.

The walls

The outside walls of the gables of the house were meant to be clad with wood to protect the clay plaster. Lime plaster and no wood was used instead, because of the aesthetics of the family. This solution is sustainable, but requires more work in the long term, because lime plaster have tendency to peel off if not properly protected.

The compost toilet

The compost toilet with urine separation was not yet installed in June 2014. The family was sceptical about having a compost toilet and did not appreciate its functions in recycling nutrients for the plants in the greenhouse. Some members of the family said that it was going to be installed eventually.

Water was not installed and thus the kitchenette and the sink in the bathroom did not function.

The greenhouse and cultivated waste water treatment system

The urine and water from the bathroom was designed to be recycled to the plants in the greenhouse. The plants should be planted on top of the three rows of clay as seedlings with roots developed to about 10 cm. Thus the top layer was made of non-capillary sand to prevent smell, and watering was not necessary with the benefits of reducing pests and weeds. However, this system was not working and not understood by the gardener. The top sandy layer was exchanged for a layer of normal fertile soil.

The planning department did not object to the system as there was no recipient to be polluted. This waste water treatment system has great potential to be widely spread as an alternative to normal sewerage, especially in areas with no sewerage mains. Next step, if the family decides to make it work, will be to get the greenhouse tested and approved by the health authorities, which could mean a breakthrough in waste water treatment systems with lots of positive consequences for reduction of pollution of waterways, energy and chemicals used in cleaning waste water, massive investments in sewerage systems and lots of concrete used. It would also mean greater empowerment of people to be able to be responsible for their own waste water and the ability to grow vegetables in a more closed loop system.

The benefit to the family would be the attention around a well functioning innovative waste water treatment system and the number of potential new customers who would come to see this for themselves.

The cold store

The cold store is supposed to be a well insulated room to keep a temperature of about 8 degrees all year round. This is done by the installation of an underground pipe that provides cool air all year round, so that the cold store does not get too hot in summer and not too cold in winter. While working there for 9 days in April, I took great care in insulating the sold store well with double layer of wood panels and 40 cm of straw in between under the roof. The last part of the insulation in the gable remained to be done. This was not completed in June and there was no understanding of why it should be well insulated. The underground pipe was blocked and therefore not functioning.

The paint

The paint on the first floor was designed to be casein paint, because it is permeable and made from natural materials, thus sustainable environmentally. However, the family had used second hand plastic paint, thus creating a less than optimal indoor environment and an unpermeable surface.

The flex oven

The flex oven was working well after workshop. Because of the chimney in the floor and the smoke washer, it was designed to have a ventilator running on the electricity by the smokewasher. Without the ventilator, the flex oven would not have any suction, as in a normal chimney were pressure in the rising hot smoke creates suction. The flex oven was demonstrated while the family was there. The chimney would end over the small pond outside.

In April 2014, the pond was covered with a plastic foil to retain water. Water had been filled in from the tap with a hose. The foil covered both the chimney exit and the drainage pipes that were meant to feed the pond with water. The family complained that the flex oven did not work and I explained that they had to reconnect the power to the ventilator and put the plastic foil under the chimney exit. They had not paid attention to how the system worked.

The smoke washer is an innovative system that has enormous potential to reduce toxic fumes and particles from wood fired stoves and ovens, thus eliminating one of the major reasons for not supporting wood burners officially in Denmark. Birkegårdens Haver could be on the forefront of this development if they understand the potential of the system that is installed in the house. The benefits could again be media attention and increased number of paying visitors.

Photovoltaics

The projected photovoltaic systems was not installed in June 2014, due to lack of finances.

Conclusion of the evaluation

I have pointed out many dysfunctions of the elements in the house and failed expectations both on the part of the family, the builder and myself.

However, the Mayer of Kalundborg County came to inaugurate the garden and the house and I was invited to speak about the building and different functions of the house. This ceremony was well carried out and there was general happiness about finalising the project and the outcome.

Seen in hindsight, the client interview should have been more elaborate to make sure the clients' expectation were clearer and that a firm consensus around the style, expenditure, design and time-frame was obtained. Each member of the family, the house coordinator (me), the builder and the planners had different visions about the house, which created some disturbances in the work. A wavering economy did not help the project and scepticism about organic materials and building methods lingered. I was hired as the house coordinator despite the fact that I hadn't built any houses before and may not have been able to explain in depth and convincingly enough all the aspects of the house. In any case, the family, at the time of decision making, bought into the different ideas and functionalities I designed for them or so it seemed.

However, at the moment of building the raw house in a workshop, the energy was exalted and everyone amazed. And as it turned out, the house was very pleasant to be inside to the great joy especially to the mother of the family. She expressed that it was a lovely house and had enjoyed decorating it and making it look romantic, like an old, cute house. She also appreciated the effect of the clay plaster inside and could feel soothing effects on the mind and the body.

In brief, the family valued the aesthetics, the prettiness and the economic return of the house higher than its functionalities. This big difference comes from the difference in understanding of permaculture, sustainability and ecological systems. If a person from the family would live in the house, the functionalities would be understood and taken care of in a different way. This brings me to believe that a green building like should have someone live in it to make all the tweaks and changes necessary to make it function, because green building design is based on a different concept of living than conventional design.

The green builders that have come to be part of the project are all very enthusiastic about the innovative designs and the functions of the house. The people visiting that have no background in green design are sometimes interested and excited about the design, while others cannot see the point.

The house and the garden are an example of how mismatch between concepts and ideas can lead to a project with many difficulties. Some of these misunderstandings might have been sorted out seen in hindsight, but at the time, we all did our best to understand each other and the project. Overall, the project was realised, the house is an attraction and the family can have time to get familiar with the different functions over time.

Reflection on the design of the strawbale house

For me, the design of the house and all its functionalities was a fantastic experience that I gained a lot of learning from on many different levels.

The whole process of understanding ecological design was a great experience and being in dialogue with one of the best ecological builders in Denmark a great privilege. I obtained knowledge of: house construction and static calculations; how to draw the designs for house construction; different attributes of materials, especially clay and straw; how to use round wood; how to build a flex oven and the concepts around clean combustion; how to build a cultivated waste water treatment system; how to build a cold store with a cool air pipe; how to use natural stones for paving; how to design a mandala garden with “edimentals”; and how to build drainage around a house.

On the level of cooperation around a big project like this I learned: the value of carefully matching expectations and outcomes; how limitations of knowledge can prevent the optimal outcome; how to better develop a project that has limited understanding from the project owners; that to make permaculture work with its functionalities they have to be “lived” not just “seen”; and that working with old conventional farmers (Birkegårdens Haver was a dairy farm before they turned towards making an income from the gardens) requires certain skills, because they expect hard physical work and does not value administrative work very highly.

I used client interviewing to get their ideas of what the house should be like. A done differently, would be to have them all sat and go through the client interview together, so that different expectation could be cleared up immediately. This was never prioritised, so I had to do interviews separately. Ideas would later come up that would change all plans again. I was acutely aware of the different needs of the family members, and responded as well as the situation and my capacity allowed.

I learned that messages have to be repeated. A family meeting with Steen Møller and me and everybody present was

held before sending in the building application. The drawings of the house were on the board. All details were taken up and discussed to make sure that everybody was on the same page. However, somehow attention must have slipped, because next time we talked about some details, the family members could not remember we had talked about the different elements and functions. This prompted me to design a model of the house together with Steen Møller and put it in a very central place, so that all could see how the house was designed. The drawings of the house were put up next to the model.

Permaculture ethics and principles are naturally central to the project and all solutions, elements and functions are guided by the principles. Produce no waste and multi-functionality are the principles the most central.

I used a normal project management cycle to guide the project: the project brief was already described in the first project application, before I was employed. Research into the different options, materials, methods, constructions, prices etc followed, with ongoing briefings and discussions with the daughter and then the rest of the family. After a construction model (the A frame) was decided upon, more research followed on the building materials, their properties, prices, where to find them, local crafts people and building regulations. Piece by piece the design came together and decision were made together with the builder and the family on how to proceed. The implementation was the two workshops. Afterwards, I have done monitoring of the house on my visits to Birkegårdens Haver.

On the level of organising workshops, I learned a lot about: invitations and media; effective communication with participants; “strawbale hotel” accommodation; giving instructions; making sure all supplies of materials, food and knowledge were available; keep people happy and ensure their needs are met; and mediation between different stakeholders.

On a personal level, I made new strong friendships with the builder, the family and workshop participants too; and I got confidence and skills to try out ecological building, but also knowing my own limitations around what it requires.

Diploma Criteria

Demonstrating Design Skills	**Applying permaculture in my own life**
- Project management and design - Stakeholder questionnaire - Ecological building criteria - Design of ecological building - Design of innovative methods	This project allowed me to work professionally with permaculture and thus obtain a livelihood. I also felt empowered through the learning and experiences to continue this work in other situations.
Learning from and developing your permaculture practice	**Applying permaculture to my work and projects**
I gained an enormous amount of learning from the building project, designing it and implementing it. Please see the Reflection above.	Using Holmgren’s domains this project has elements of “Land and nature stewardship”, “Building”, “Tools and technology”, “Education and culture”, “Health and spiritual well-being” and touches upon “Finances and economics”. With regards to the permaculture categories this design would be mainly in site design and

	development.

Appendix

Client Interview

Questions regarding building the strawbale house

Some of these questions were answered in the original project description, others from dialogue around the house design and some from a direct client interview. The builder of the house, Steen Møller, a professional workshop leader, also had ideas, limitations, preferences and visions of his own. We found a photo of a house built like we wanted to build it, because seeing a photo is often more valuable than words. Also, I built a model of the house together with Steen Møller to make sure that the details were agreed upon. The family liked the house style and we went on to design the details of the house.

What are the client's needs and wants?

- A house, made from organic materials, which meets the budget.
- The house should be able to accommodate having lectures and workshops.
- The house should accommodate the daughter of the house.
- The house should be used for renting out for a week to people who wants to try living in a straw bale house.
- The house should be integrated with the garden and fulfil the functions of a cold storage space, greenhouse, tea kitchen, compost toilet with sink.
- Further details as described in the original and additional funding applications.

What are the client's values and vision?

- A smallish, cute house "Morten Korch" style. Not "Viking-like".
- A house that can attract visitors
- A house that can create publicity and media attention
- Permaculture as a way to promote Birkegårdens Haver's green initiatives and failing economy
- A house built from organic materials.

What are their personal resources and limiting factors?

- A limited budget as set in the original project document
- Two people working part time to complete house and garden, including obtaining planning permission
- One person taking care of administrative matters
- One person with strong views of aesthetics and ideas for the house and garden
- One person part time with practical skills and a bobcat
- Two employees that can work on the house if released from their normal work at Birkegårdens Haver

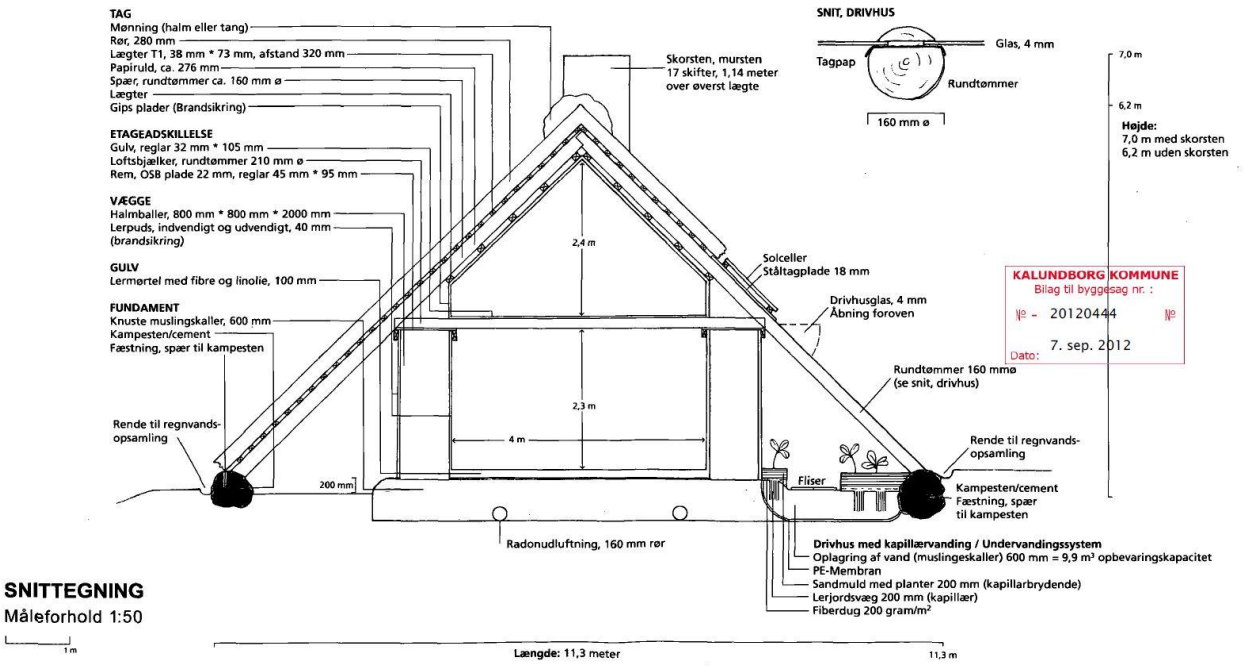
What is their timescale for the design?

- The time-scale is set in the project description to two years – April 2012 to May 2014.

Site-related details?

- Planning permission for rural areas needs to be obtained
- Protection lines from a burials site, a forest and a water course must be respected.
- Maximum height of the house is 7 meters

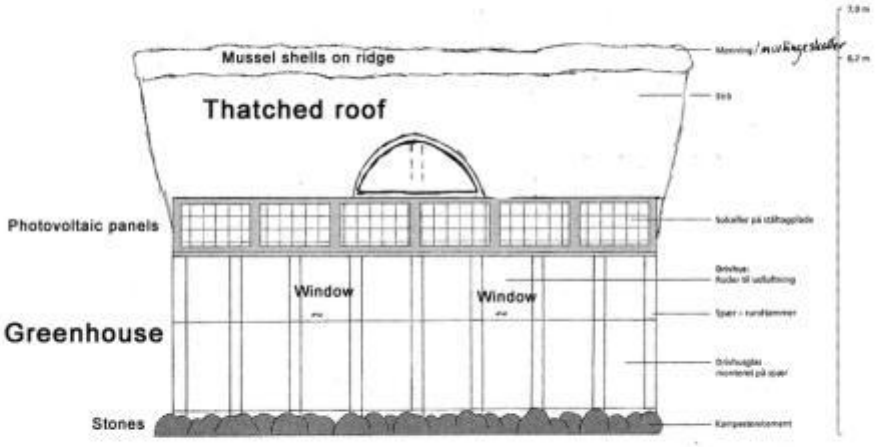
Construction design drawings for the house approved by Kalundborg County



The design of the house, cross section. For translation please read the description page 15.

HALMBALLEHUS / PERMAHAVEN

BIRKEGÅRDENS HAVER
– oplevelseshaver, dyr og legepark ★★★★

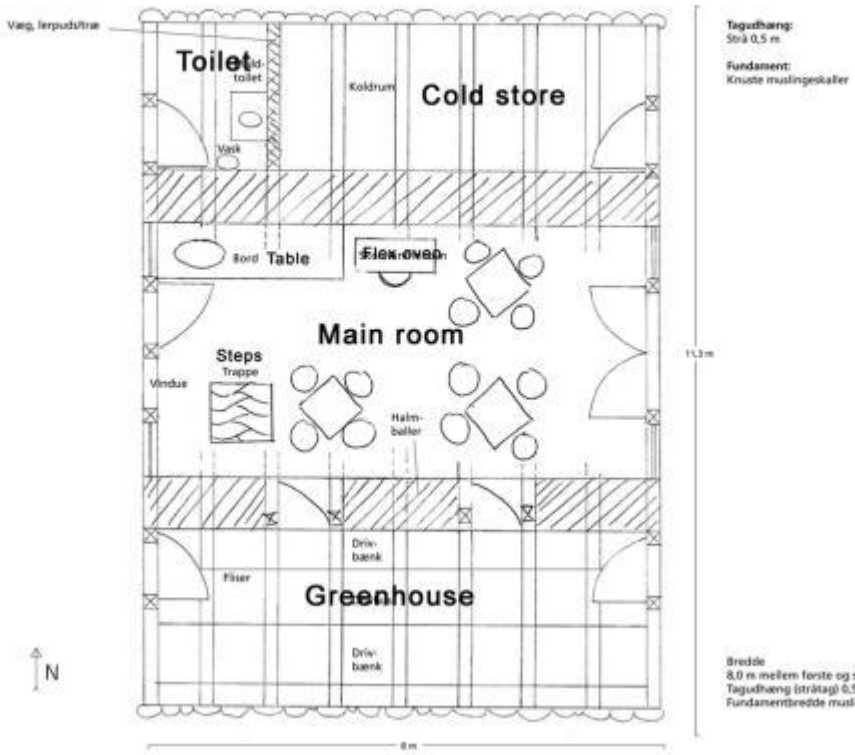


FACADE / SYD
Måleforhold 1:50

South facing facade

HALMBALLEHUS / PERMAHAVEN

BIRKEGÅRDENS HAVER
– oplevelseshaver, dyr og legepark ★★★★



PLANTEGNING
Måleforhold 1:50

N

HALMBALLEHUS / PERMAHAVEN

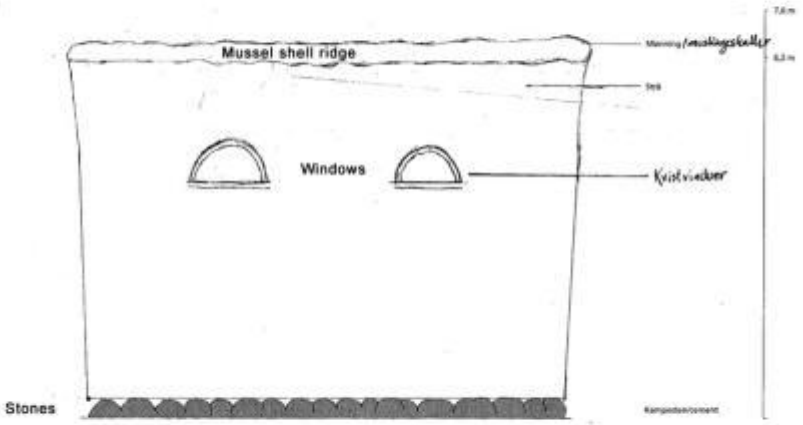
BIRKEGÅRDENS HAVER
– oplevelseshaver, dyr og legepark ★★★★

Loft

LOFT
Måleforhold 1:50

HALMBALLEHUS / PERMAHAVEN

BIRKEGÅRDENS HAVER
– oplevelseshaver, dyr og legepark ★★★★

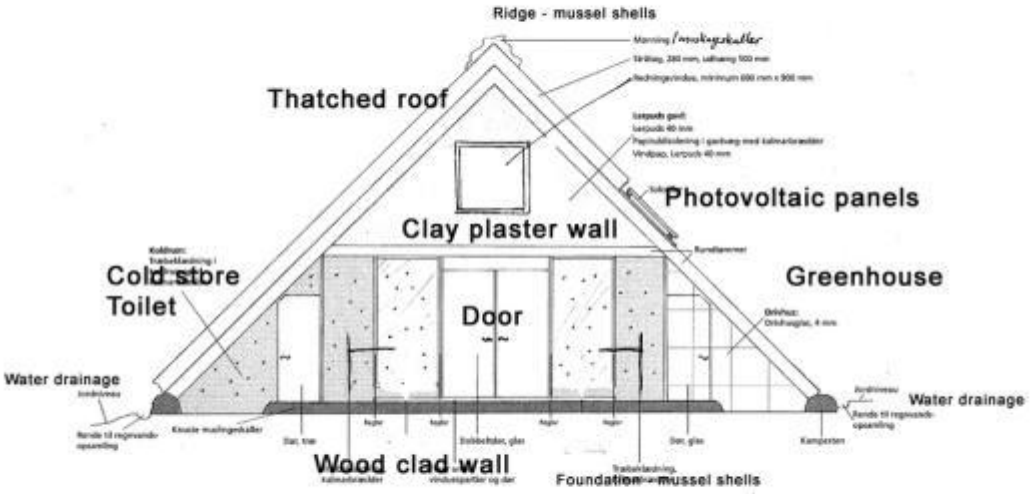


North facing facade

FACADE / NORD
Måleforhold 1:50

HALMBALLEHUS / PERMAHAVEN

BIRKEGÅRDENS HAVER
– oplevelseshaver, dyr og legepark ★★★★



West (and east) facing walls

FACADE / VEST (DET ER DET SAMME MEN SPEJLVENDT)
Måleforhold 1:50 OBS: Vest: 1 dør + 1 vindue i samme dimensioner. (0.93 cm + 2.12 m)