THE ROTVOLL PROJECT

CAMPHILL Rotvoll is a broad interdisciplinary effort in which all the participants are driven by a strong environmental engagement and a desire to raise awareness and increase competency regarding sustainable architecture in the building sector and society in general. The project aims to complete Scandinavia`s first retrofit of a single unit building to zero-energy standards.

ASSIGNMENT 03 GROUP 05

The project is taking the urban planning issues, for instants rehabilitation concept, energy infrastructure, solar access/shading, wind conditions, noise. The layout and building form should be designed with efficiency of space use, compactness, thermal zoning, daylight access, ventilation strategies, passive heating and cooling air distribution. In order to design the envelope there should be great consideration of glazing area, windows size and placement, solar shading, daylighting systems and ventilation openings. An efficient heating cooling, ventilation and lighting system design strategies are also some other important aspects to keep in mind. Last but not least, the building structure and materials are important in order to keep low emissions, easy maintenance and low embodied energy.

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ENERGYPROJECT2
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I.Introduction

To have a better understanding of the aim of this project we need to go back to roots of a Camphill, what is a Camphill?
A Camphill is not only a class, a lecture room or a workplace but a community. A community there people with especial needs can learn to be independent. People with either psychological or physical disability need not only a family but “a community” to get on their feet. Imagine a world there everyone can feel safe, comfortable and get ready to take a step further in their lives. To create a world, a community, a family environment and a home requires a total awareness of the especial needs of these unique people. To create this especial environment we need to start with keywords in this project, “universal design of building”. This means anyone in any physical or psychological disability can without any problem live in a building, and especially in a Camphill building.

A. Background

After two excursions at two of Camphills and seeing closely the Rotvoll barn and the site, I have now a much better understanding of aim of a Camphill. We should not only design a dwelling but also a place that disable students with especial needs can work, feel unique and learn to be more and more independent.

The existing buildings that are suggested for refurbishment are actually barn with no insulating envelope and in bad construction conditions that need most likely to be demolish and rebuilt to contain any housing or living areas.
The barn is an area with 1200 m^2 with great potential for universal Design and good sun access. The Camphill Rotvoll needs residential homes with hall, seminar rooms, café and workshops (such as tissues, herbs and bakery), care homes for young people who take vocational education, adults who live and work on Rotvoll. The project aims to provide a hands housing as environmental demonstration and meeting facilities.

B. Proposals and discussions

Meeting with the engineering students 21.02.2012
In order to be able to design the optimal functional building for Camphill, it is extremely important to have a good overview of all issues and problems that should be in consideration to archive good functional design for the students. That is why we arranged a meeting with the engineering students to try to find good solutions from an engineering point of view and get a best possible starting point.
We are facing a very complex project that not only requires good architecture but mostly good functional design. This is not only a building for housing but a workplace, office, concert hall and most importantly an “optimal environment” for people with especial needs.
It is important to set back and try to see it from an engineering point of view and see the challenges that facing them in this building.
We presented our two solutions for organization of different functional areas to the engineering students. The first proposal divided workshops, private apartments, a kitchen and school locals in different part of the barn geographical. One major problem with this solution is having for example having workshops and lecture rooms in at least to different floors and this might be an everyday challenge for disable students and students with wheelchairs to go up and down in different floors from time to time. This solution also limited in a way which there will be a challenge to keep apart the private apartments from common areas like classrooms and workshops. It means that we need to place the private

areas in the end parts of the buildings that this keep the privacy of the private areas from people walking throw or crossing by to get to the other common areas.
And the second solution takes this previous problem into account, this solutions divides areas into 2 major parts; one more private areas like apartments and then there is more common areas/rooms like lecture rooms and workshops. By placing the private areas in second floor and common areas at the first floor, the students/inhabitants in this case will need to move to first floor for lectures or workshop once in a day and it may give them less challenges with stairs and lifts.

Meeting with the engineering students 27.02.2012
Today we talked more about which of the two proposals the engineering students should calculate the energy budget for. We decided that the proposal with different geographical zones should be our priority number 1. One important reason for this proposal is because of the integration of the double skin façade in the building which will have a major impact on annual energy demand, especially on summer seasons but also partly in autumn and spring.
The engineering students will provide some calculations, based on our drawings in, and calculate the performance of the building.
We also discussed different energy production sources and talked about most efficient solutions. For example, Photovoltaic is most likely less efficient in Norway compared to Solar collector that will save until 50% of energy used for domestic water heating. We have also decided to present different energy sources and strategies and write a brief conclusion on our opinion.

C. Comments from engineering students

Comments and feedbacks from the engineering students:
After presenting our solutions we asked the engineers for feedback and tips for the building and what is important to take into considerations when we design.
They mentioned a technical room of around 15 m^2 that is good to have as central as possible in the building. Because of the less pipes from the heating source that gives both most efficiency, less pump and less dimensions for the pipes. We also asked if we could place such a room at the second floor or in the attic, they will come back with an answer later. We also discussed how much glass areas we can have in our building and according to Norwegian regulation it is not recommended to have more than 20% of heated floor area (BRA) with glazing areas.
We also tried to figure out how many energy sources we have in disposition for our project. We have access to district heating, water to water heat pump from sea, geothermal, traditional air heat pump, solar collector and photovoltaic panels.

Next day we got some conformation from students;

A technical room on ground floor or below is needed. (For heated water tank, District heating terminal, etc.)

- We want the ventilation aggregate to be placed in the loft, Possible 3 aggregates. (1 for each living unit + 1 for the common area) A stair of some sort is needed to gain access.

- We do not think the aggregates will occupy much space, but all of the loft area cannot be used for living rooms.

- We will use the U-values from passive house standard to get the energy budget from simien. (together with room plans)

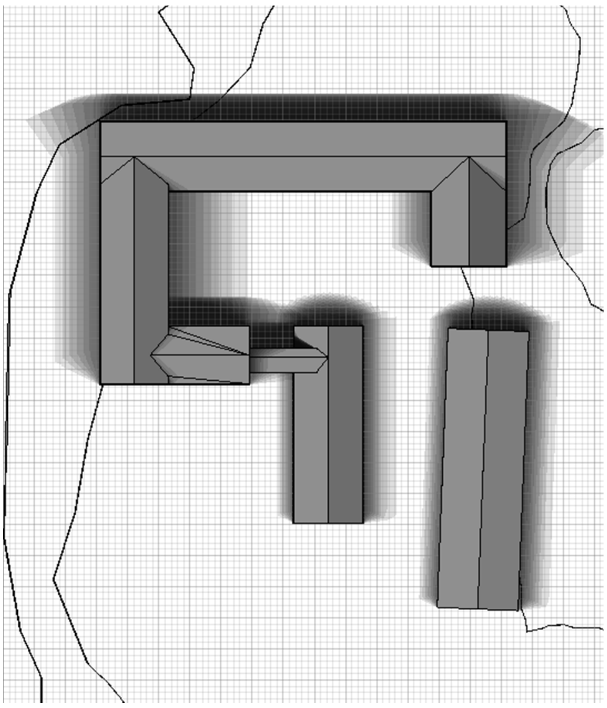
- As we mentioned window and doors together can be max 20% of living floor area (BRA) (building codes)

- Also it was mentioned that room height should not be below 2.3 m if it should feel comfortable.

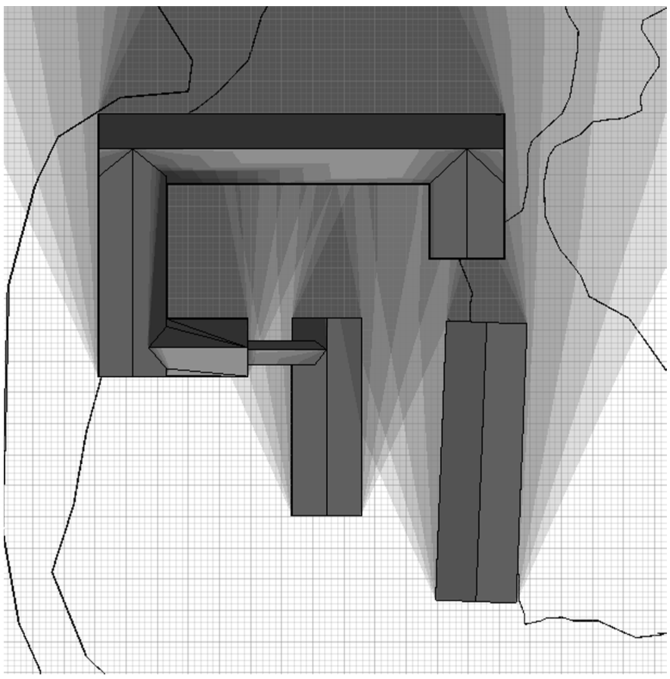
II.Site analysis

To be able to understand and integrate the energy to the design of a building is important to have good overview of what sources and issues exist on site and how can we design to integrate our building to the site and it`s conditions. There are abstractions that might cause less sun radiation/direct sun light and this will again have an impact on passive heating, cooling and lighting strategies. Here is where "Integrated energy design" should play a major role for our design strategy. Understanding the site our building will be built on is the first step to "integrated energy design". It is about utilize the sources and possibilities on site that will make your building more efficient in terms of less annual energy consumption, better air and lighting quality.

A. Shadow analysis



Midsummer shadows



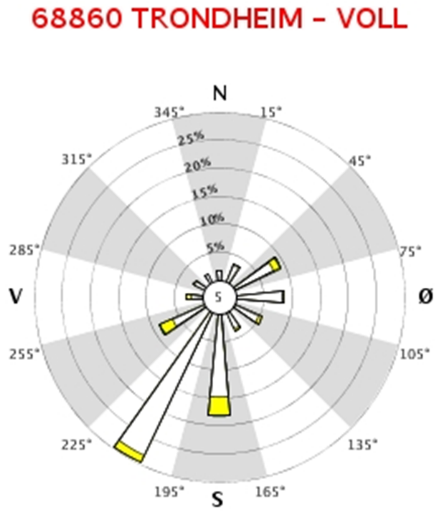
Midwinter shadows

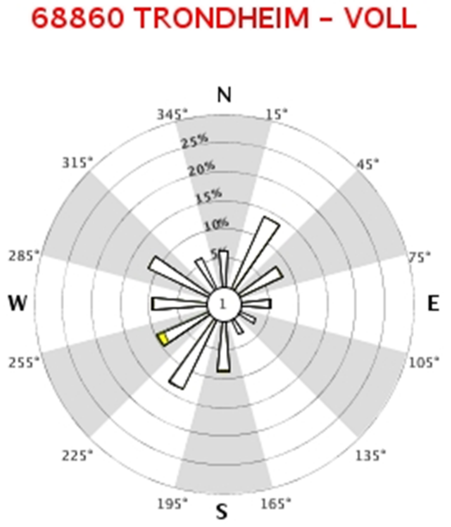
We used Ecotect analysis and imported the specific position (latitude and longitude) of Trondheim for sun or shadows analysis. As we can see there are some subtractions on south side of our building that will cause some extra shadows in winter. These shadows are in the reality good to have since the low sun rays does not really heat up in the midwinter. In the other hand it will be necessary to shade for these low sun rays since it will cause glare and bad living/working condition.

B. Climate analysis

Every site has its own issues and challenges that might affect a building both in good and bad way. The key here is to deal with them in an early stage of a design process. Pavilion wind direction in combination of exposed surrounding hills and not to forget the closeness of Rotvoll to the sea, are just a few climatic issues to be considered.
On the other hand we have some existing roads, constructions and trees to consider.
On major problem that has a lot bigger effect on a building than the others, is the wind and infiltration heat losses. The first heat exchange process in air infiltration is the passage of outside air through cracks around windows and doors or other openings in house walls or ceilings. One way outside air is forced through these openings is by pressure differences caused by wind on the outside of the home.
Air pressures on surfaces that face the wind are subject to increased air pressure as wind velocity increases. Air enters the home through openings in these surfaces. This forces an equal amount of interior air out of the home through openings that face away from the wind.

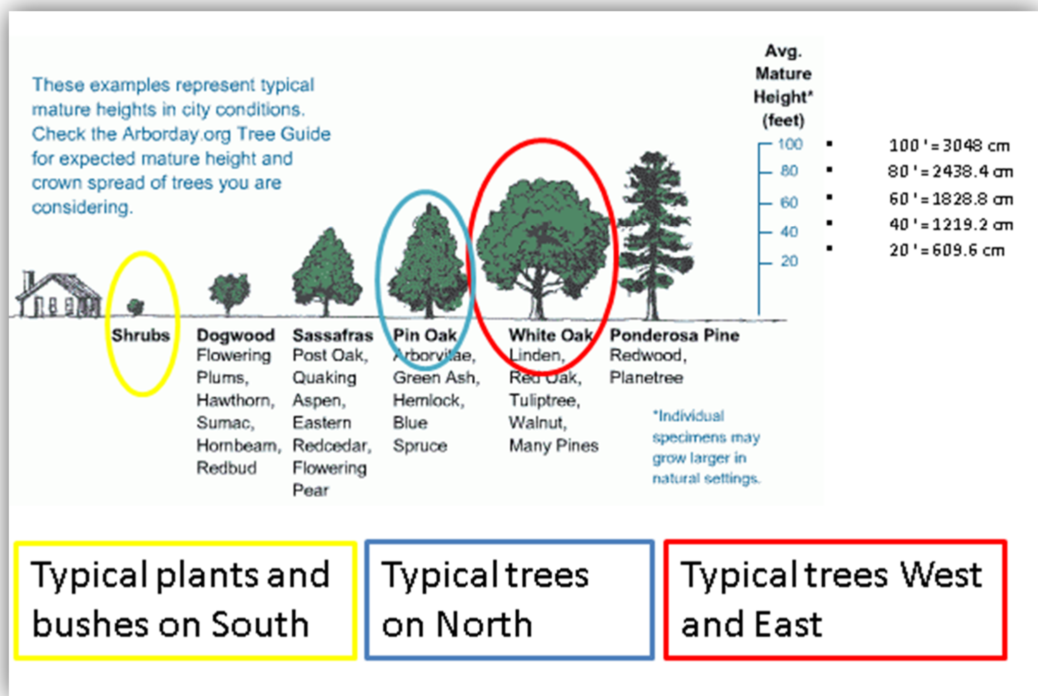
In winter, heat losses due to air infiltration may represent up to half of the total heat losses on the windiest, coldest days. Properly placed plants can reduce air infiltration by reducing wind velocity near the home.
Proper use of trees, shrubs, vines and man-made structures can modify the climate around your home to reduce heat gains in summer and heat losses in winter. Plants can protect your home from winter winds and shade it from summer sun. Winter heating bills may be reduced as much as 25 percent and summer cooling bills 50 percent or more. According to researches (from book Heating, Cooling, Lighting) if we manage to reduce wind seed hitting our building with trees and plants with 25% so will we archive until 50% less heat losses throw infiltration.
In order to archive very low heat losses (which is the major focus in Nordic climates like Trondheim) we need to analyze the existing trees on site and try to develop it with more and better placed plants/trees in our advantage and second stage is a 100% airtight building.





On left diagram we can see the pavilion wind

density and direction in the winter for last 10 years and on right we have the same for the summers. As we can see in the winters we have one direction that needs to be considered more carefully than the others, which is southwest (and south). Although this direction is very important to keep open towards sun rays to archive best possible passive heating strategy.
We know that sun rays coming from west and east are usually low and have less energy to heat our building but it is anyway good for natural daylighting to allow these rays to reach a building. In order to archive low sun radiation in winter and summer winds to penetrate we suggest trees high canopy. These trees in combination with low evergreen shrubs are good protection against winter winds from southwest and south and in the same time letting low sun radiation to pass through and reach our building for passing heating of inside environment. Also distance of these trees are extremely important, according to researches (Heating, Cooling, Lighting) the distance between a building and trees or plant should not be more than 4 times of a tree`s height to reduce the infiltration heat losses of the building
On the other hand we have a quite mixed wind directions in summers that means we have very good cross ventilation opportunities all around our building.
These issues do not seem to be important for many of the designers and architects but in a world of "integrated energy design" it should also be carefully considered and most importantly before future work of design process.



Here are some typical trees with their height.

III. Design Proposal

A. Background

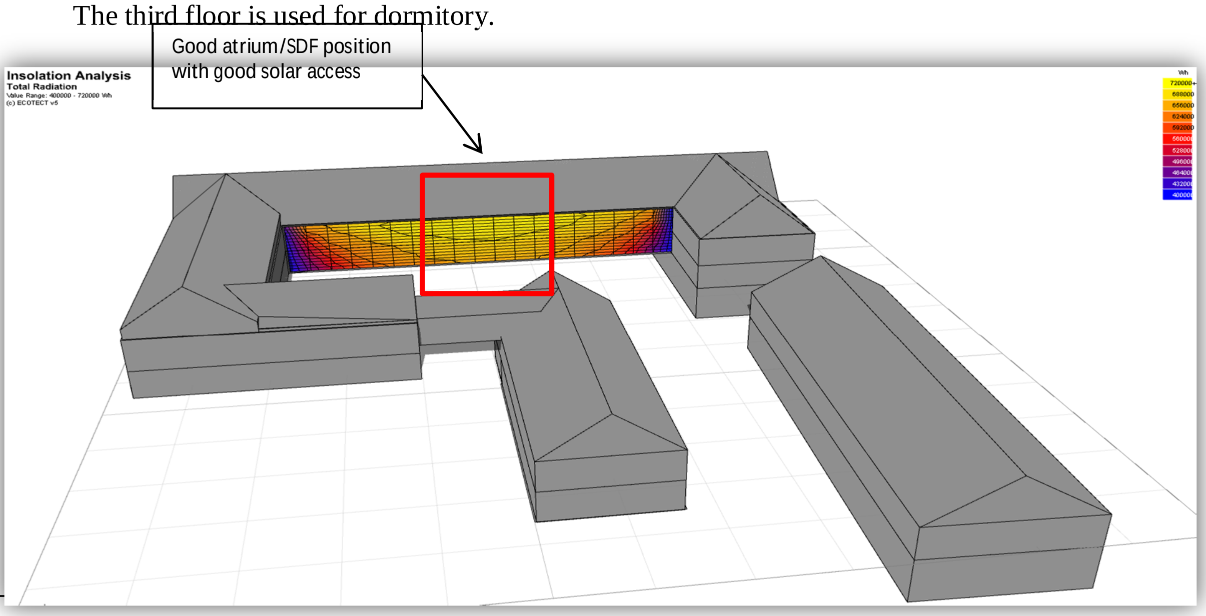
On the excursion, special emphasis put on importance of providing privacy for students considering their dependency to custodian. In other words while they need to be watched carefully and get help, they need to have their own independent life. Thereby in the first proposal, the zoning of different functions is based on the level of their privacy. The other factor which shaped this proposal is the building's long narrow U-shape and how it interacts and connects to its surrounding.

B. Concept and Analysis

Four main points formed the concept for this building:

- Zoning the building based on level of privacy of different functions.
- The U-shape of the building and its interaction to the outside.
- To keep the external shape and integrate the internal elements in new building as the interior design elements.
- Simplicity and easy connection to different zones with regards to disability of the students.

According to the functions and the shape of the building, it is divided into 3 main zones; east zone, central part and west zone.
The east zone is next to the existing school, the public parking lot and a road leading to the beach. Compared to other zones, it is more crowded and exposed to traffic due to the existing building and the beach. Three main properties of this zone are the good view to the beach access from the road and adjacency to the school and parking lot. This zone consists of three floors; the multifunctional room in the basement, workout room and workshop in the second floor and café, kitchen and canteen in the first floor.
In the central zone, the office, lecture rooms, library and workshops, are located, which are mainly used by resident[1] and tenant students[2] as well as teachers and parents. It is the longest façade towards south, so it is more exposed to the sunlight and prepares good internal environment. The double-height atrium as the entrance lobby separates this zone from the east zone which is more public.
In the west zone, family houses are located in the first and second floor with separate entrance and parking area. Also the tenant student dormitory in the third floor is accessible through this zone in the east facade. Here we are less exposed to common areas and have a good view to hill and sunlight in the afternoon which creates perfect ambience for the evening gathering.
The third floor is used for dormitory.



[1] Students live in dormitory for 2 years and are more independent.
[2] Students live with the family for longer time maybe whole life and are more dependent.

Materials

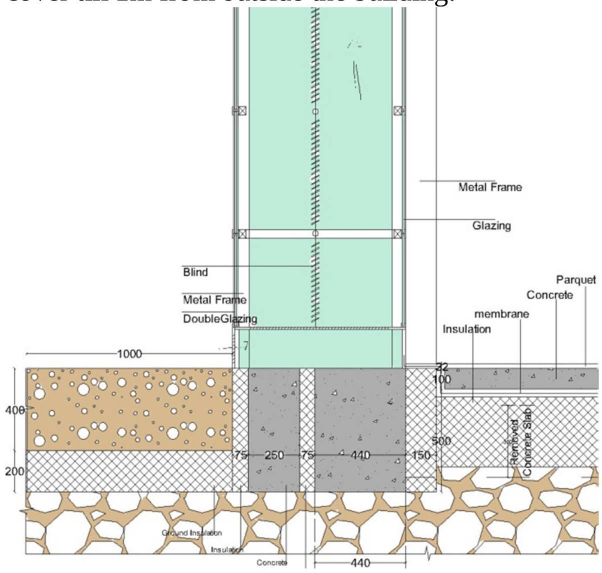
The proposed building material for the structure is “Glulam”. Due to its greater tensile strength, the existing columns can be eliminated and the load of the slab can be shifted onto the walls. The existing beams are not removed in order to maintain the interior of the building but while the load is shifted to the walls, these beams will act as design elements only. The wood from the existing structure can be used, as the glulam is renewable resource and has high fire performance and moisture control characteristics.

IV.Construction details

As discussed earlier, the main ideology behind refurbishment of Rotvoll building is to maintain the older structure as much as possible. But it intrigues a lot of challenges in order to attain passive house standard.

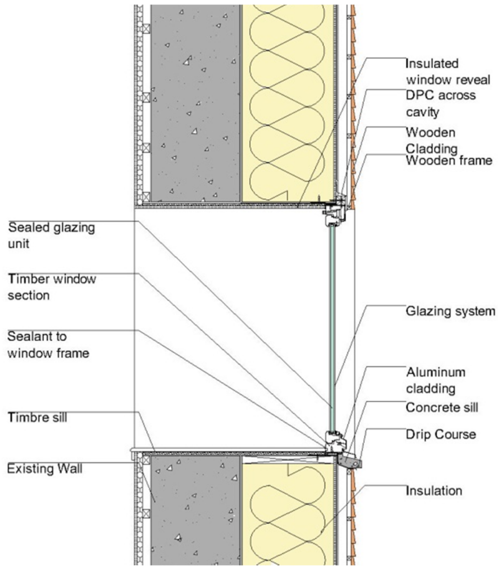
A. Floor Insulation

The existing floor is not insulated so in order to protect it from the ground the reinforced floor has to be chipped off to a certain thickness, layout the insulation of 350mm of thickness and above it 100mm RCC floor is to be laid. With the existing conditions and the temperature difference from outside and inside surfaces, the appearance of moisture on the surface is highly likely. Thus, necessary membranes are also to be provided between the construction layers of the floor.
The floor is also to be protected from the both sides by providing insulation and extra concrete foundation pad to the wall structure. The insulation bed should be laid outside the foundation of the walls and it should cover till 1m from outside the building.



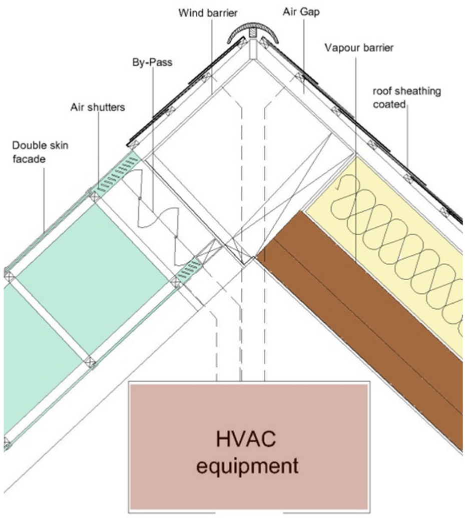
B. Construction of walls and Air-tightness of windows

The necessary measures have to be taken in order to get complete air-tightness of windows and doors should be attained. The gunned in-sealants are to be incorporated in order to seal gaps around windows/doors and the surrounding wall externally to prevent air leakage. The air tight membrane should overlap the seal to maintain the air tight layer. The triple glazed windows are to be used in order to get high efficiency. The window sills and lintels should be protected with thermal insulation, wind and vapor barriers.



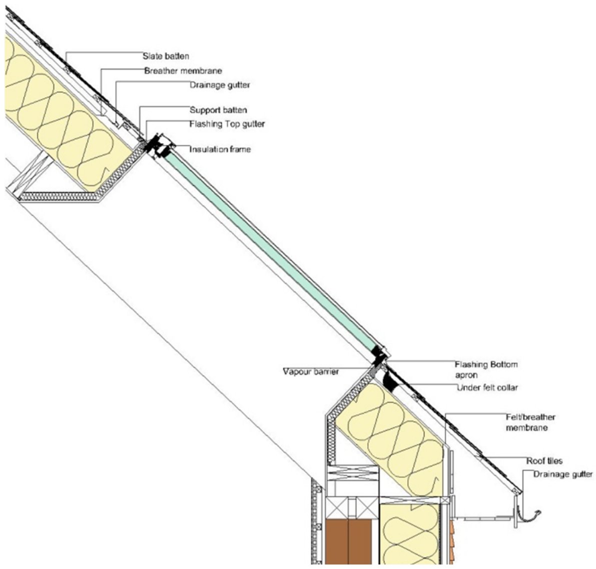
C. Roof

The roof should be insulated, protected with vapor membrane and airtight with air strips and compatible sealants. In our proposed design, the double skin protected buffer space is incorporated in the building. So the roofing system is to be improvised in order to get maximum efficiency. The attic space is ventilated with an air gap to get "cool roof effect". The insulation is protected with both vapor and wind barrier. The point where the roof meets the double skin façade system, the air shutters are to be provided for the free flow of air within the cavity. The roof should be airtight and surrounds are sealed where they penetrate the air barrier.



D. Skylight window

Special care should be taken in case while installing skylight windows. The window should be sealed with appropriate flashings. The drainage gutter should be provided on the top of the window to cater the rain water flow on the roof. The window should be stabilized with support batten frame and an under felt collar. Roof insulation is to be protected with the extra insulation frame on all side of the window.



V.Energy strategies and calculations part 01

A. Requirements

1. Requirements regarding passive house standard in Norway

Countries around the world have different guidelines for energy efficiency buildings. Since our building is situated in Norway we have to follow the Norwegian requirements.

To achieve passive house standard in Norway the requirements are high.
Sintef byggforsk did a study in 2010, the title was "Comparison and Analysis of Energy Performance Requirements in Buildings in the Nordic Countries and Europe)" in the summary they stated the following:

- Norway appears to have the tightest overall minimum requirements for U-values of individual building components in Europe, probably also the world, just ahead of Sweden. Finland has the tightest minimum requirements for windows.

- Norway has the strongest focus on robust building envelopes (i.e. long-term energy measures that reduce heating & cooling demand, such as U-values and heat recovery), as a result of limiting net energy demand [kWh/m² yr] as opposed to primary energy use. Net energy demand is independent of the energy supply system (e.g. boiler or heat pump efficiency or use of renewables).

This illustrates that the focus on energy saving in buildings is taken serious by the Norwegian government.
When construct a building in Norway you always have to fulfill the requirements stated in the "FOR 2010-03-26 nr 489: Forskrift om tekniske krav til byggverk (Byggteknisk forskrift)". In short context this is called byggteknisk forskrift, TEK10. The number is the year that the regulations take effect from. Before TEK10 there was TEK07. The regulation includes topics like environment, indoor climate, ventilation, fire safety, availability, energy use and heat loss, building construction etc.
To achieve passive house additional requirements has to be fulfilled. The requirements can be found in the NS3700. This is a national standard made in 2010.
In NS3700 the following criteria is presented:

2. U-values:

Property	value
U-value external wall	≤0.15 W/(m^{2}K)
U-value roof	≤0.13 W/(m^{2}K)
U-value floor	≤0.15 W/(m^{2}K)
U-value window	≤0.80 W/(m^{2}K)
U-value door	≤0.80 W/(m^{2}K)
Normalized thermal bridge- value	≤0.03 W/(m^{2}K)
Yearly mean temperature efficiency for the heat recovery unit	≥80 %
SFP- factor ventilation system[1]	≤1.5 kW/(m^3/s)
Leakage number when 50 Pa, n_{50}	≤0.6 h^{-1}

[1)] SFP is specific fan power.
How to calculate the values for a building is stated in NS3031

3. Requirements regard to net energy demands:

Yearly mean temperature θ_{ym}	Highest calculated net energy demand for heating [kWh/m^{2}year]	
	Private house where A_{fl}< 250 m^2	Private house where A_{fl}≥250 m^2
≥6.3 °C	$15 + 5.4 \times \frac{(250 - A_{fl})}{100}$	15
<6.3 °C	$15 + 5.4 \times \frac{(250 - A_{fl})}{100} + \left(2.1 + 0.59 \times \frac{(250 - A_{fl})}{100}\right) \times (6.3 - \theta_{ym})$	$15 + 2.1 \times (6.3 - \theta_{ym})$

A_{fl} is heated part of the BRA. BRA is available area for a building excluding open roofed area.
The Bra is calculated after the method in NS3940.

4. Energy supply:

For passive house it is required that appreciable part of the heating system can use other sources than electricity and fossil fuel.

$$E_{del,el} + E_{del,oil} + E_{del,gas} < E_t - 0.5 \times Q_{W,nd}$$

Where

$E_{del,el}$ is energy from yearly delivered electricity in kWh/year

$E_{del,\ oil}$ is energy from yearly delivered fossil oil in kWh/year

$E_{del,\ gas}$ is energy from yearly delivered fossil gas in kWh/year

E_t is the total yearly net energy demand in kWh/year

$Q_{W,nd}$ is yearly net energy demand for heating of the domestic water

In addition TEK10 states that the house has to have a power supply other than electricity to support the heating and ventilation.

5. Heat loss value

H" [W/(m^{2}K)

Private house where A_{fl}<100 m^2	Private house where 100 m^2≤A_{fl}<250 m^2	Private house where A_{fl}≥250 m^2
0.6	0.55	0.50

6. Cooling:

The building shall be created in a way so thermal comfort can be obtain without mechanical cooling and/or supply air supported by cooling machines. Note that passive free cooling to obtain thermal comfort is not a part of the definition of mechanical cooling.

Indoor climate:

The regulation for indoor climate is stated in TEK10. In general the building should have ventilation adjusted to the rooms' pollution- and humidity load so that satisfying air quality can be obtained. The indoor air shall not contain pollution in noxious amount in consideration for health and irritation risk. The air supply must be adjusted after type of room, furnishing, equipment, persons and domestic animals.

The following statements have to be fulfilled:

a) The buildings ventilation system shall be located in a way so the air quality can be secured. If the outdoor air is too polluted so it can be a health risk the air has to be filtered before entering the building.
b) Pollution amount from persons in the room has to be considered when dimensioning the ventilation system.
c) The air guide has to be from a room with high air quality regulations to a room with lower air quality regulations.
d) Air inlet and air outlet has to be placed and designed so the two airs will not be mixed and the inlet air is polluted as little as possible.
e) Polluting activity shall, as far as possible be enclosed and equipped with local exhaust ventilation, or place in own premises with its own ventilation system.
f) Recirculating are shall not be used if it leads to transferring of pollution air between rooms.
g) Materials and products shall have qualities that give low or no pollution to the indoor air.

Every living unit shall have ventilation that ensure an average fresh air supply at minimum 1.2 m^3 per hour per m^2 floor area when the unit is in use and minimum 0.7 m^3 per hour per m^2 floor area if the unit is not in use. The supply of fresh air to bedrooms has to be 26 m^3 per hour per bed unit when the room is in use.
Thermal indoor climate in room for enduring stay shall be adjusted due to health and satisfying comfort with provided use.
In rooms for enduring stay at least one window or a door faced to the outside has to be able to be opened.
Buildings and connecting user area shall be projected in such way that persons get satisfactory sound and vibration conditions taking presumed activity into account. It shall be ensured opportunities for work, rest, sleep, concentration, communication and apprehension of warning signals.
Technical installations in buildings has to be placed, so it ensure satisfactory sound level both inside the building and outside on the belonging area.

B. Energy budget

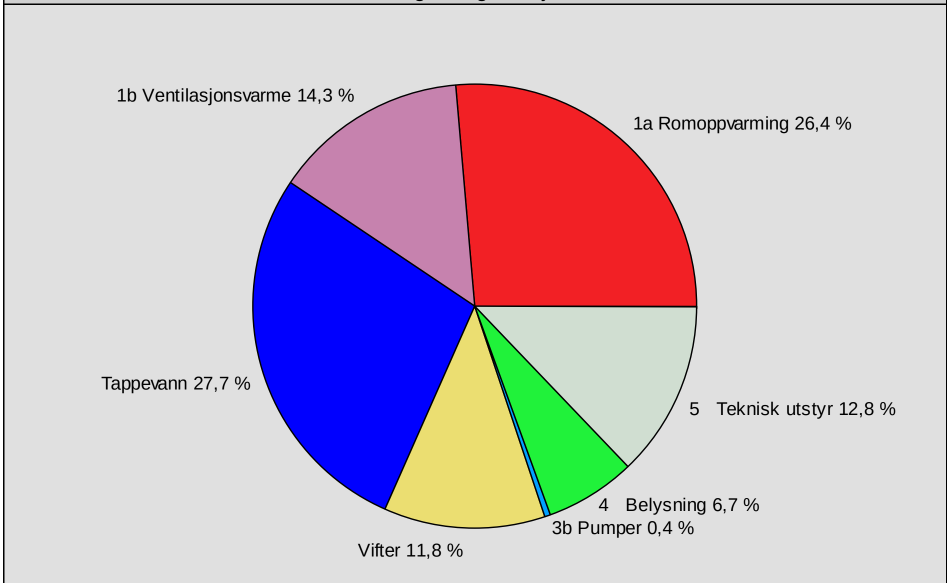
The energy budget is calculated in Simien. Building category is selected as residential building. There are several rooms simulated on each floor. Energy use for tap water and room heating is large compared to lightning, pumps, fans and other technical equipment. Energy for heating can be provided by other sources than electricity, for example renewable sources from the environment around the building.
The dual layer wall is calculated as a big window in Simien. This may lead to wrong estimates of indoor temperature and energy assumptions.

The energy delivered to the building can be less than the energy demand, by using efficient energy sources and technical installations.

At the moment the energy budget exceeds the allowed value for the passive house standard, and some adjustments are needed to achieve the standard.

Energibudsjett		
Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	111251 kWh	30,2 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	60082 kWh	16,3 kWh/m²
2 Varmtvann (tappevann)	116858 kWh	31,7 kWh/m²
3a Vifter	49543 kWh	13,4 kWh/m²
3b Pumper	1649 kWh	0,4 kWh/m²
4 Belysning	28083 kWh	7,6 kWh/m²
5 Teknisk utstyr	54005 kWh	14,6 kWh/m²
6a Romkjøling	0 kWh	0,0 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	0 kWh	0,0 kWh/m²
Totalt netto energibehov, sum 1-6	421471 kWh	114,3 kWh/m²

Årlig energibudsjett



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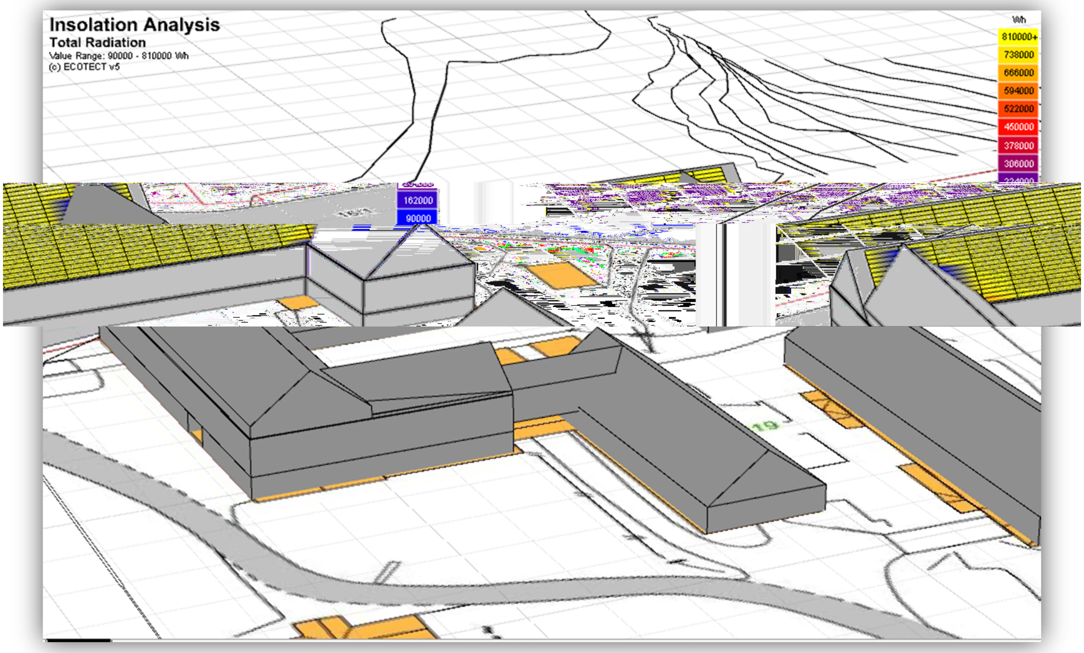
Totalt netto energibehov, sum 1-6	421471 kWh

C. Energy production and sources

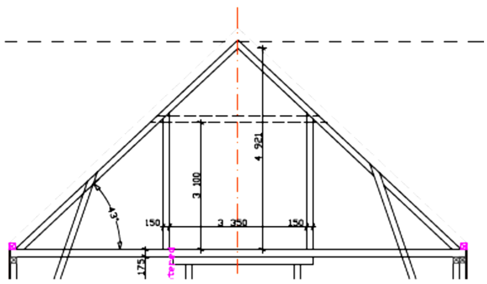
1- Photovoltaic



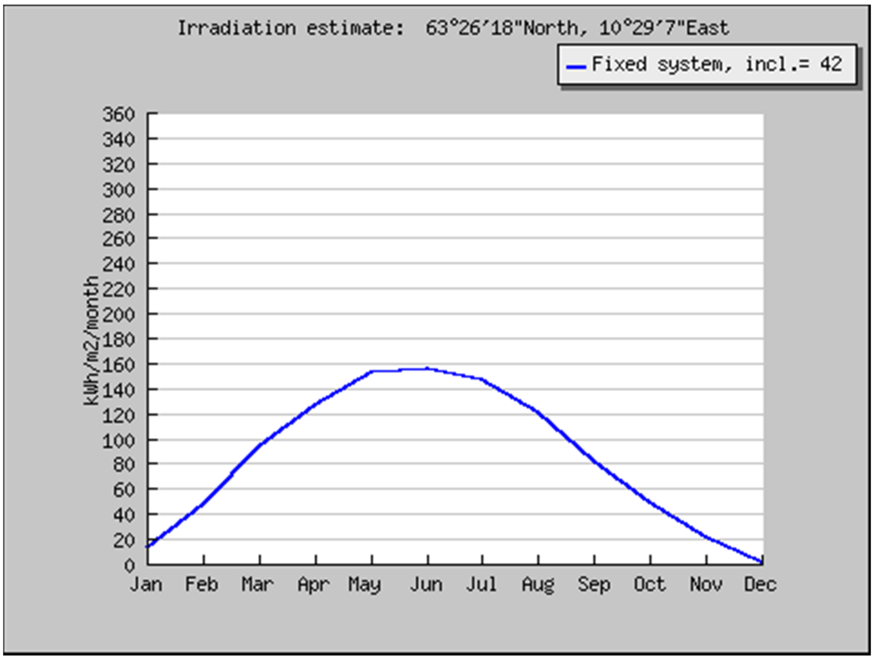
As we saw from shadow analysis we have a great position for PV panels on roof of south facing with minimum abstractions and best angel for PV panel.
There are many ways to calculate the solar access of specific surface, we used Ecotect Analysis. With Solar access analysis we analyzed how much exposed/solar gain in term of watt hours we have on the roof.
We have also checked the website for “Photovoltaic Geographical Information System” and got it confirmed that an angel of 43 degrees is the optimal angel for integrated PV panels in building. It is also very good to notice that the existing building roof has actually the optimal angel of 43 degrees for PV panels.

Performance of Grid-connected PV
PVGIS estimates of solar electricity generation
Location: 63°25'49" North, 10°23'42" East, Elevation: 18 m a.s.l.,
Solar radiation database used: PVGIS-classic
Nominal power of the PV system: 1.0 kW (crystalline silicon)
Estimated losses due to temperature: 12.0% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 3.0%
Other losses (cables, inverter etc.): 14.0%. Combined PV system losses: 26.6%

Fixed system: inclination=42°, orientation=0° (Optimum at given orientation)				
Month	E_d	E_m	H_d	H_m
Jan	0.35	10.8	0.43	13.2
Feb	1.35	37.9	1.67	46.7
Mar	2.36	73.0	3.02	93.7
Apr	3.14	94.1	4.24	127
May	3.54	110	4.94	153
Jun	3.62	109	5.19	156
Jul	3.29	102	4.73	147
Aug	2.74	84.9	3.89	121
Sep	2.02	60.5	2.72	81.6
Oct	1.22	37.9	1.57	48.8
Nov	0.58	17.3	0.71	21.3
Dec	0.01	0.384	0.04	1.35
Yearly average	**2.02**	**61.4**	**2.77**	**84.2**
Total for year		**737**		**1010**



Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)



2- Wind power

The kinetic energy of wind can be harnessed by using wind generators to produce wind power. The interest for building integrated wind power in Europe has increased the last few years. The plants can either be connected to the electricity grid or not. If connected, it is possible to sell surplus power. Commonly used wind turbines for small-scale wind power production are turbines with horizontal or vertical shaft.

Wind turbines with horizontal shaft is the most common turbin type and they look like miniatures of the wind mills used in big wind farms. They are suitable for places with steady wind from a dominating direction. The turbine is rotationable to ensure that the power generating propeller is faces against the wind and the size varies from 100 W to 15 kW. The amount of energy produced depends on the installed capacity and wind speed.

Wind turbines wih vertical shaft can use wind from all directions without having to rotate. This makes them suitable in places with turbulent wind. Producers of this type claim that they make less noice than the horizontal ones.

Installation

The wind turbine is more effective the higher over ground level it is mounted and the less the wind gets disturbed. Small wind turbines are usually mounted 3 to 4 metres above the roof of a building or on freestanding beams ehich can reach up to 16 metres.

Reliability of supply

Since the wind speed and direction varies, the supply system also is dependent on other energy sources when connected to the grid. Systems that are not connected to the grid is dependent on a storage medium to power supply failiure when there is no wind.

Building integrated windmills in Norway

There are only a few building integrated windmills in use in Norway today. In 2011 there was nearly nobody who built singlestanding or building integrated wind turbines.

Economy

The investment cost for small-scale wind power varies, but is usually above 20 000 kr/kW. A system for subsidies for this type of installation does not exist in Norway today.

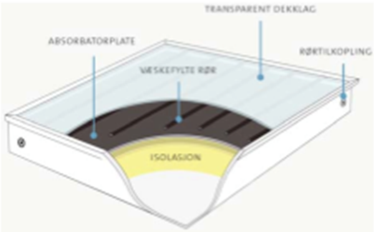
Potential at Rotvoll

Trondheim has one dominating wind direction as shown in the wind rose. This makes the wind turbin with the horizontal shaft suitable for our building. The surrounding area is used for framing and recreation, which makes wind turbines mounted on the roof a more suitable option.

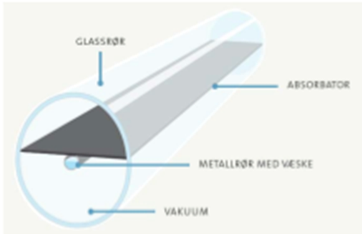
3- Sun collectors

Basic theory

Sun collectors are an alternative to regular PV-panels to extract usable energy from the sun. A system using sun collectors will use the energy from the sun to heat a liquid, often water, or air. Unlike PV-panels that produce electricity, sun collector's aim is to produce low valued energy that is suited for such tasks as hot water, or room heating through radiators, sealing or floor heating. Where the PV-panels efficiency is not very good with high income sunrays! The sun collectors have no real issues in that regards. This also leads to the possibility of combined PV/T-panel systems where pipes with the working medium are found behind the PV-panel.



Figur 13: Prinsipiell oppbygging av plan solfanger [1].



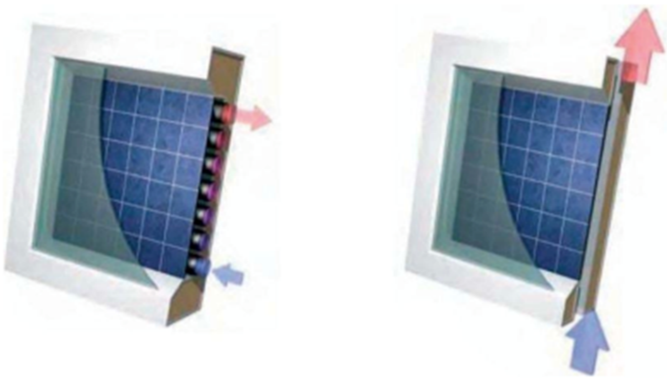
Figur 14: Snitt gjennom en vakuumrørsolfanger med direkte gjennomstrømning [1].

Such a system would produce more energy per surface area used then either of the system alone, but it is more complex and if an error occurs, it could have effects beyond just local.

Types

When it comes to sun collectors we generally speak about two types; the plane collector and the vacuum-pipe collector.

The plane collector is the most widely used one, and also the cheapest of the two alternatives. It should ideally be used where the need for the hot water temperature is in the range 30-80 °C.



Figur 25: Prinsippløsning for væskebasert PV/T og luftbasert PV/T [25]

The vacuum-pipe collector has a lower heat loss, and a higher efficiency. This makes it possible to produce water in the range 50-150 °C, and it is an alternative that is most suited for a very cold climate.

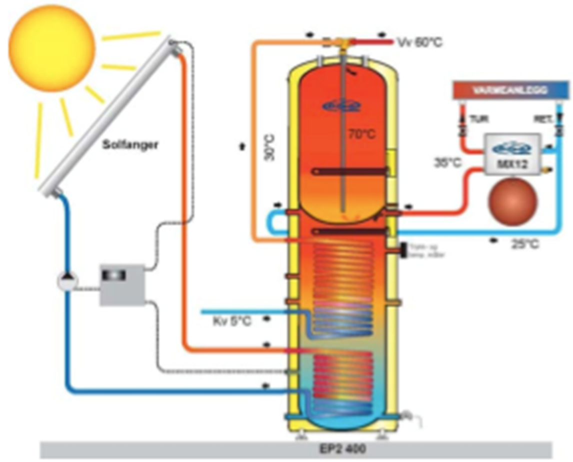
Installation

The sun collector, heating-storage-tank, distribution system and control system build up the installation of a sun collector.

Like PV-panels the ideal positioning in Trondheim is estimated to be facing south and with an angle of 43°. The most common places to install the panels are on top of the roof, or on the facade.

Heat-storage

Sunenergy was never a stable source of energy for common use, and its lack of presense when it is needed forces us to have a way to store the energy produced at the peak, for off-peak periods. This is commonly done by short storage in hot water tanks that is connected to the sun collector systen with a heat exchanger.
In bigger systems it is possible to use buffer tanks for storage. This means that it is stored in a seperate tank from the hot water tank, and only submit heat to the hot water tank when it is needed.
A typical system for a residential building with 4-6 m^{2} heat collectors would have about 300-400 liter of storage-tank, circulation pump and automated control system.



Figur 20: Prinsippskisse for korttidslagring i vanntank med tilkobling til solfanger [21].

Economy

An Enova-survey shows that an estimated investment cost will be about 11kr/kWh produced heat per year for a hot water system, and 15kr/kWh for a combined system for hot water and room heating.
The investment costs for a plane collector is on average 2000 kr/m^ {2} of the sun collectors area, while the average cost for a vacuum-pipe solution would be about 3000 kr/m^ {2).
A heat storage tank is also estimated to be on average 30 kr /liter.

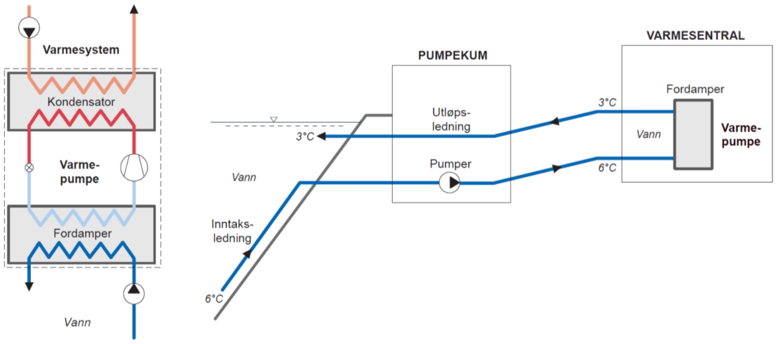
Potential

In Norway it is possible for a good dimensioned system in a residential building to produce 300-700 kWh per m^ {2} sun-collector-area per year, considering all heat produced in the summer can be utilized.
Systems for only hot water heating can be dimensioned to cover 40-50% of the yearly hot water heating demand.
A combined system for hot water and room heating can typically cover 25-30% of the yearly energy demand.

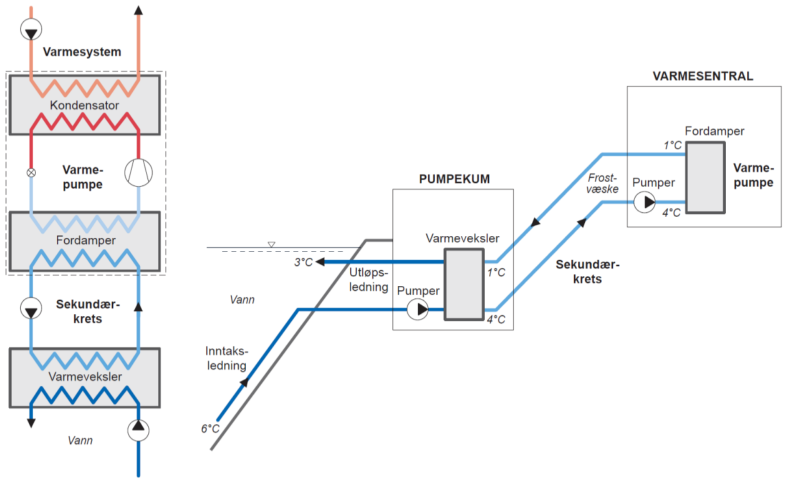
4- Heat pump with sea water as heat source

The Rotvoll building is in proximity to the sea, which makes seawater a possible heat source for a heat pump.
Using sea water as heat source gives several **advantages**: Seawater never drops below -3dgC, in comparison to air that holds a dimensioning outdoor temperature at -19dgC in Trondheim. The temperature of air varies a lot more. The COP drops with higher temperature differences between source and condensation temperature. In addition the longevity on the equipment drops when the temperature differences changes often (this is the case with air-air, or air-water heat pumps)
The specific heat of water is 4 times higher than air that means 1 kg water holds 4 times more heat than 1 kg air. This does not matter much for air as it is an unlimited amount of

source. For water it matters as power is needed to pump the water or glycol-water mixture to the building, which in our case is over 100 meter.
The sea water is also an excellent **heat sink during summer.**
Disadvantages: The investment costs are higher than a system with air as heat source. This is because the system is more complex. A sea water intake on the sea floor is needed, a pumping station, and sea water heat exchangers. A secondary circuit of fluid is also often used.
The greatest challenges to the heat source system are **corrosion, freezing, clogging and fouling.** The system has to be designed to avoid these problems as much as possible.
There are two principal ways to collect heat from seawater**: Direct** and **indirect ystem.**
Direct: The working fluid in the heat pump evaporates directly against the sea water.



Indirect: The sea water exchanges heat to a secondary circuit containing frost resistant fluid (water-glycol). This fluid exchanges heat with the working fluid in the evaporator.



The direct solution demands a frost and corrosion resistant evaporator, but has the lowest investment costs and is thermodynamically the best. If the evaporator is damaged, sea water will flood the working fluid circuit, causing serious damage to the machinery.
The indirect solution has a higher investment cost, but is more secure against freezing. It benefits when the height difference between the house and sea is high. A point is that static height can't be recovered when sea water is returned after use.

5- District heating in Trondheim

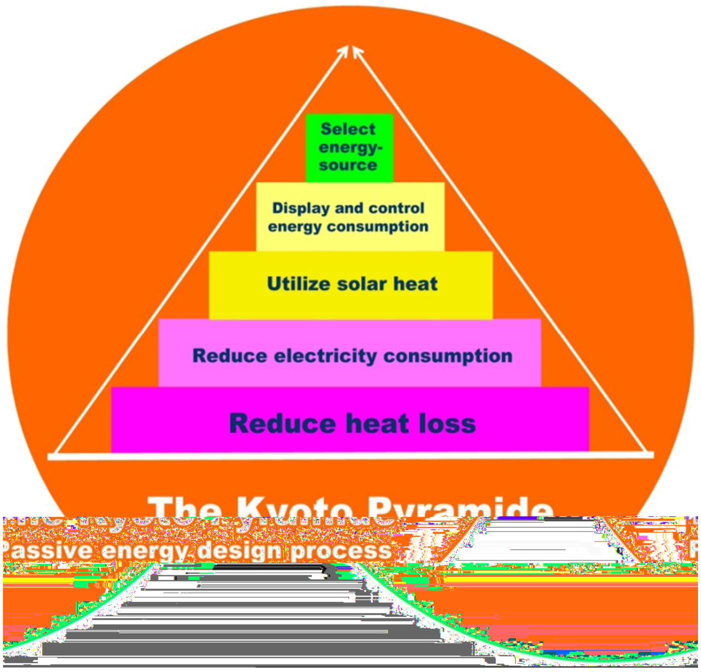
District heating is one of the most reliable heating sources in Trondheim and main pipe line of district heating is close to Rotvoll Camphill. The energy provider company is “Trondheim Energi Fjernvarme AS”:

This company provide district heating to about 6000 homes and 600 businesses and public buildings. District heating supply covers approx. 30% of Trondheim's heating needs. The company currently has 78 employees.
Trondheim Energi AS District's goal is to have an environmentally sound and flexible energy supply. The company has extensive expertise in the development and operation of district heating and waste disposal, and they are a leader in the field.
District heating in Trondheim produced using different energy sources. Since 2008 the proportion of waste is between 70 and 80% and In addition, biomass, heat pumps, landfill gas, natural gas (LNG), propane / butane gas (LPG), electricity and some heating oil.
District heating is recommended especially for larger buildings like schools, kinder gardens, offices and lager apartment buildings. In our case this might be the best and most effective and reliable heating source. As we have already mentioned, 70-80% of heating is from waste, with low effect or damage on the site near Rotvoll Camphill for power production. It is also very important to mention that this heating solution has lowest need for additional electricity to function compared to the other heating suggestions.

D. Conclusion Part 01

Environmental concept and strategies

The refurbishment and retrofit of the Camphill Rotvoll barn are the occasion to set sustainable environmental goals for the development.
Our approach aims to follow the design strategy leads by the Kyoto Pyramid, developed by Dokka and Rødsjø in 2005.
This mainly means make use of passive strategies that enable the building to consume less energy and accordingly reduce emissions damaging to the environment. In the early concept design stage, we decided to achieve the passive house standard. This standard requires an annual heating consumption lower than 15 kWh/ (m²a) and a total. Primary energy consumption lower than 120 kWh/(m²a) for heat, hot water and electricity (lighting and appliances).



In the same time, we want this building to be ready for

further upgrades in the future. We are taking into account, different local sustainable energy resources that can be used further to achieve more performing standard such as Zero Emission Building or Plus Energy.
After good consideration of the all possible sustainable energy sources for Rotvoll Camphill, we can say that most reliable heating source is District Heating. It has minimum changes/damages on site and is from 70-80% waste energy.
We have also great wall surfaces towards south and it gives us good conditions for solar collectors. That is why we have good reason for choosing solar collectors for domestic water heating. But we will still need high grad energy in form of electricity. There are many Photovoltaic panels that have good efficiency but in a cold climate like Trondheim and limitations on south facing roof areas. This is the main reason why this building cannot be plus Energy building today and most likely should wait for either another electricity source or much more efficient PV. Otherwise we need very large area for PV to produce high grad energy/electricity to verify Rotvoll Camphill as Plus building, which is not possible today or will not be cost-efficient. It is also important to remember that this old bar is a protected and preserved by Norwegian preservation authorities. This gives us many challenges to keep the existing shape and in the same time produce enough energy to make it sufficient. And here the “Integrated Energy Design” comes in; we have to integrate both active and passive facilities/installations into existing building shape and elements. This way we have maintained the shape of the barn and because of the good compact shape, get PHPP verification and energy label A according to Norwegian Standard (NS 3031).

Highly insulated and airtight exterior walls, roof and ground floor are the basis to achieve passive house standard.
To supply the remaining energy demand we should rely on solar panels and solar collectors. The amount of these panels and the use of other solutions, such as for example a small wind turbine, will depend on cost priorities of our clients according to suitable standard to achieve at the beginning (Passive House, Zero Emission Building, Plus Energy).

Life cycle assessment is taking into account looking for local materials to reduce transport emission and reclaiming old materials of the existing construction both to use it in the new interiors and to store it for user workshops purpose to reduce new materials fabric emissions.

We want to threat grey water onsite, cleaning it through a water treatment wetland from where it will be directed the sea.

VI. Energy strategies and calculation Part 02

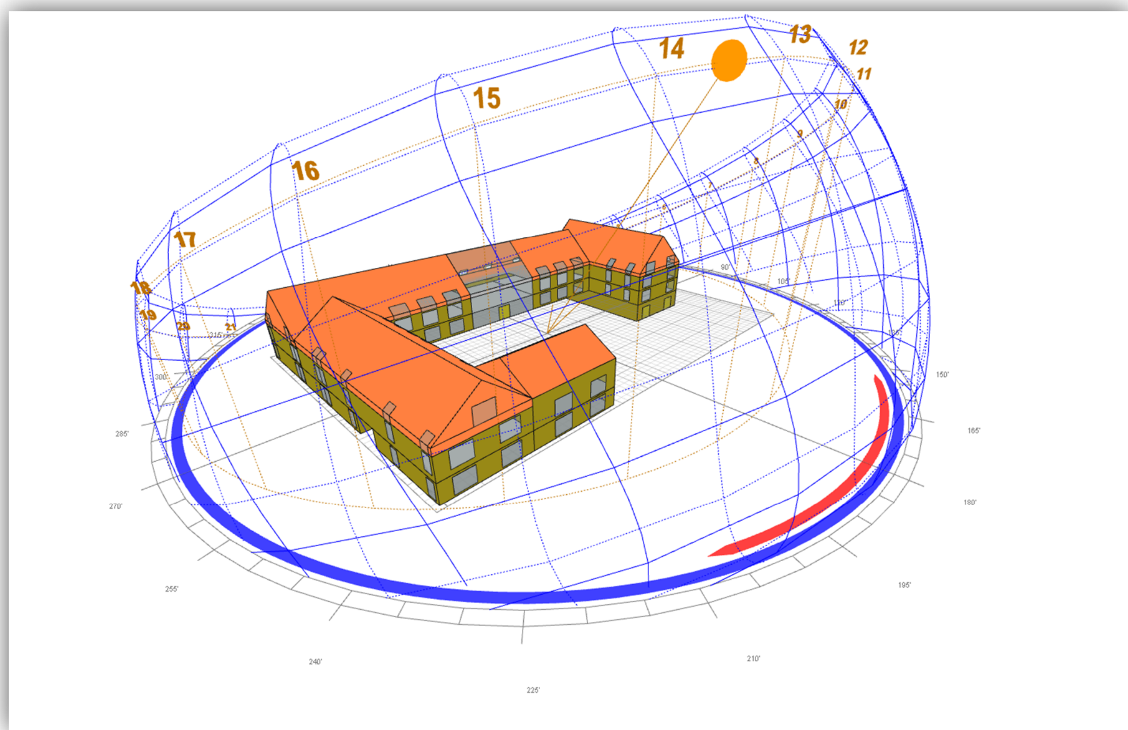
After carefully and briefly analysis of both the energy and design point of view, we finally made decisions for future calculation. We have performed calculation of the energy demand and overall performance of the building, according to two different and independent tools, both Norwegian Standard NS 3031/Ecotect analysis 2011 and Passive House Planning Package calculation tool.

A. Requirements

As we mentioned before in Part 01, we have Norwegian Passive House Standard requirements such as U-values for all the building elements, ventilation and operation.
We have decided to use the products and producers in Norwegian market to in the both calculation methods (NS 3031 and PHPP). At the end of the report we will mention all the products used in calculation from the Norwegian marked.

B. "Calculation of energy performance of buildings, NS3031"

The calculation according NS 3031 started in Ecotect analysis 2011 software. We designed a model of Rotvoll barn in the program and specified the U-values of the building materials and geographical location of the site. In Ecotect we also specified a ventilation system with an efficiency rate of 94% (given in software) with heat recovery unit. Based on these specifications we got Watt hours the building will need in different months. Based on limitations of the software, it is not possible to calculate and add the heat contribution of the double skin façade placed in front of the atrium; neither will it have any better effect on total performance of the building in Ecotect analysis.



As we can see we have also decided to have different window sizes based on which direction they are pointing at.
South facing windows have a width of 2500mm and 2000mm height. This is the largest window size of all the walls (except the Atrium).
For east and west facing windows, it is important to remember how the sun rays will strike the windows. The sun radiation is always at its lowest level when they are shining from these directions. To get as much as possible natural light into the rooms it is important to have a

vertically longer windows. This is the reason we decided to have windows with a width of 1250mm and a height of 2000mm.
And finally on north facing façade we decided to have as small as possible windows since no sun radiation exists from north. But we still need to have some windows towards north to keep good living conditions of the rooms facing north. On the other hand we have very good landscape on northeast of the building, facing the sea and hills. So on this façade the key is the view and not passive heating or natural light from sky. The dimensions of north facing windows are 1600mm width and 1000mm height. With this dimension we have good sideways view of the site and the sea on north.

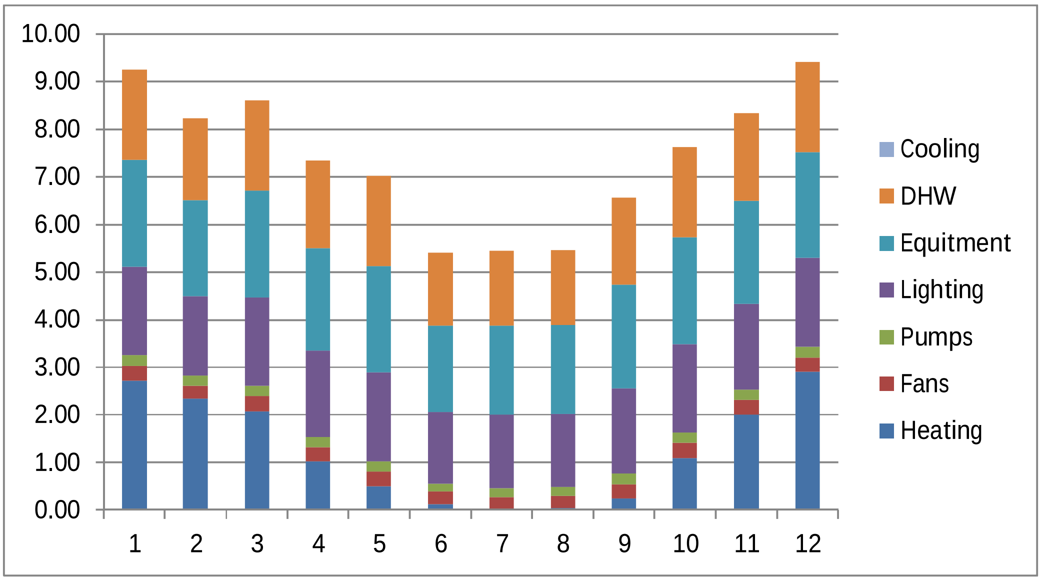
1- Building function and category specifications
According to the standard we need to specify a category for our building which we can calculate the energy demand, delivered energy and label our building. When we look at the tables for energy demand for lighting, equipment and hot water we can see that the demand is highest for lighting and equipment for school, office and university building and hot water demand is highest for dwelling or residential purposes.
Lighting: demand for residential buildings are 1.95 W/m^2 and for university or office buildings are 8 W/m^2. Here we choice a number between and decide it to be 5 W/m^2.
Equipment: demand here vary very much between different building categories, residential buildings is 3 W/m^2 and for office buildings is 11 W/m^2. But in our opinion our building in section is much closer to a school building which is 6 W/m^2.
Domestic hot water: in this section we can just imagine which category has the highest demand. Building in residential category has the highest demand with 5.1 W/m^2, which is used in our calculations.

2- Standard values for operation hours of different building categories
It is difficult for a building like Rotvoll Camphill to decide which category the building belongs to. According to NS the time of operation for a residential building is 16 hours, 7 days and 52 weeks of a year and for school building is 10 hours, 5 days and 44 weeks. As we know our building is around 50% residential and other 50% is a mix of workplaces, school and offices. We are decided that operation hours in one day should be 12 hours in 7 days of a week and 9 months (except 3 summer months) of a year. In the rest of 3 months in summer we can allow to go down to 12 hours of operation hours

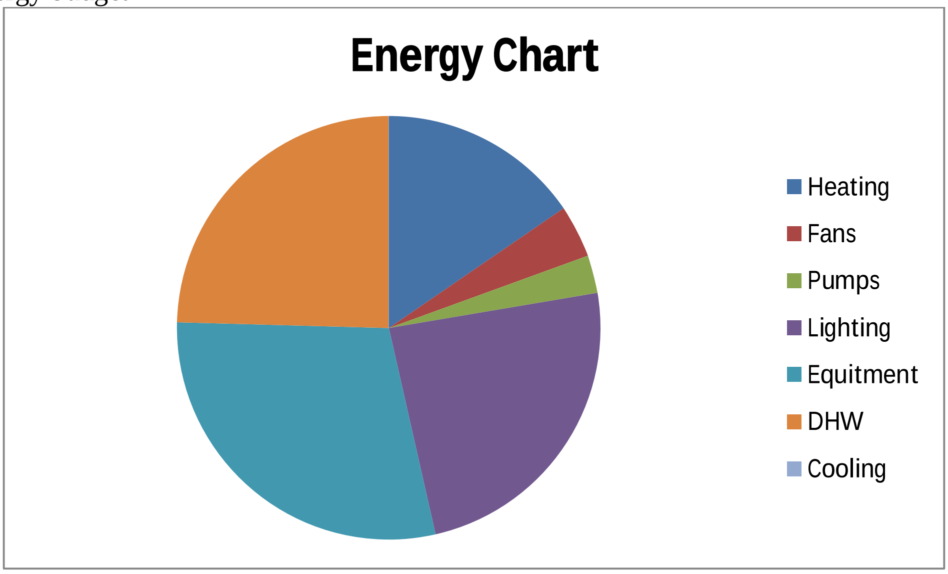
3- Total energy demand

Max Cooling: 0.0 C - No Cooling.													W/m^2	W/m^2	W/m^2		
													5	6	5.1		
	HEATING	COOLING	TOTAL				Days/month	Hours/day	Hours/month	Heating	Fans	Pumps	Lighting	Equitment	DHW	Cooling	
MONTH	(Wh)	(Wh)	(Wh)		m^2		days	h	h	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	
------------	---------	--------	---------														
Jan	9564771	0	9564771		3513.98		31	12	372	2.72	0.31	0.22	1.86	2.23	1.90	0	
Feb	8207727	0	8207727		3513.98		28	12	336	2.34	0.28	0.20	1.68	2.02	1.71	0	
Mar	7309466	0	7309466		3513.98		31	12	372	2.08	0.31	0.22	1.86	2.23	1.90	0	
Apr	3600446	0	3600446		3513.98		30	12	360	1.02	0.30	0.22	1.80	2.16	1.84	0	
May	1756723	0	1756723		3513.98		31	12	372	0.50	0.31	0.22	1.86	2.23	1.90	0	
Jun	473603	0	473603		3513.98		30	10	300	0.13	0.25	0.18	1.50	1.80	1.53	0	
Jul	50730	0	50730		3513.98		31	10	310	0.01	0.26	0.19	1.55	1.86	1.58	0	
Aug	120823	0	120823		3513.98		31	10	310	0.03	0.26	0.19	1.55	1.86	1.58	0	
Sep	881342	0	881342		3513.98		30	12	360	0.25	0.30	0.22	1.80	2.16	1.84	0	
Oct	3869214	0	3869214		3513.98		31	12	372	1.10	0.31	0.22	1.86	2.23	1.90	0	
Nov	7088748	0	7088748		3513.98		30	12	360	2.02	0.30	0.22	1.80	2.16	1.84	0	
Dec	10180866	0	10180866		3513.98		31	12	372	2.90	0.31	0.22	1.86	2.23	1.90	0	
------------	---------	--------	---------														
TOTAL	53104456	0	53104456				365	138	4196	15.11234	3.496667	2.5176	20.98	25.176	21.3996	0	
------------	---------	--------	---------										Total energy demand			311627.4991	kWh/yr
PER M²	13768	0	13768														
Floor Area:	3513.98																
Fans:					Pumps:												
Von	1.2	m^3/(m^2*h)															
SFPon	2.5	kW/(m^3/s)			SPP	0.5	kW/(l/s)										
ti,on					Vw	0.6	l/s										
Vred		small houses dont need red			tdr	0.002	h										
SFPred		small houses dont need red															

Total energy demand according to NS3031 is 311 627.5 kWh/year.



4- Energy budget



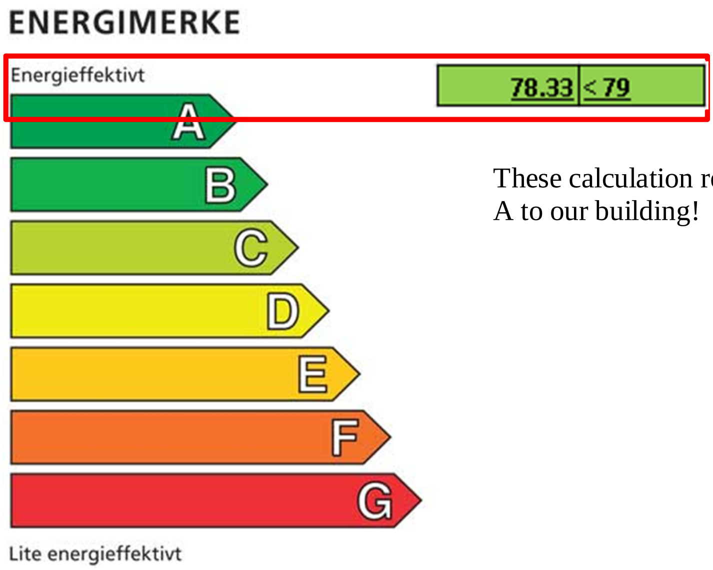
5- Calculated delivered energy

Heating systems					**Electricity systems**				
	DHW *fW*	H *fH*							
Solar collector *f.,T-sol*	0.6	0	n.T-sol	10	PV (*f.El-sol*)	0.1	n.El-sol	100	
District heating *f*, dh	0.4	1	ndh	0.86	Grid	0.9			
					kWh	*kWh/m²*	*kWh/m²*		
Delivered electricity for el-specific demand				Edel,spec-el	165176.07				
Delivered electricity for solar thermal system				Edel,sol-el	4511.87				
Delivered electricity Edel, el					**169687.94**				
Delivered district heating				**Edel, dh**	**105568.02**				
Total delivered energy				**ET**	**275255.95**				

As we can see from the table above, we are expecting that domestic hot water is covered 60% by solar collector and rest 40% by District heating. We have also PV installed on south facing roofs and we are expecting to produce about 10% of electricity demand of the building by PV panels.

Total delivered energy is 275 256 kWh/year.

6- Energy label



These calculation results will gives us energy label A to our building!

7- CO2 emissions

Energy Carrier	CO2 factor			
	g/kWh	kWh	kg/year	kg/m2
District Heating	231	112717.08	26037.65	
Electricity from power network	395	145739.88	57567.25	
Total CO2 emission			**83604.90**	**23.79208**

C. Passive House Planning Package

1- Introduction

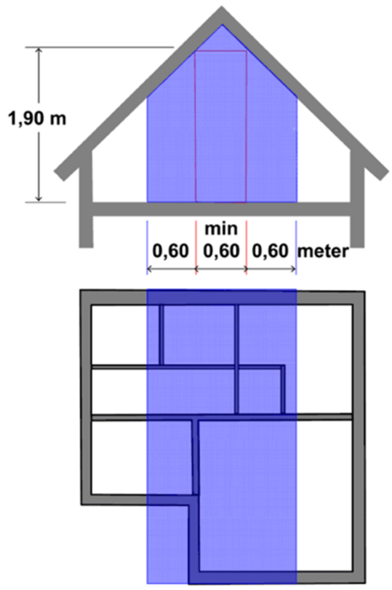
PHPP is a simplified energy performance worksheet for architects to have an understanding of how good performed a building they are designing really is. This calculation worksheet is containing different sheets for different building elements, facilities and functions that have impact on energy performance of a building. For example by specifying different u-values for different construction elements, HVAC, DHW storage/handling, shading and heating source, we can at the end get a verification that shows whatever our building can be verified as a Passive House or not.

2- “Brief introduction”

In this sheet we can see how all the sheets are supposed to be filled and also a name list of all the sheets and whatever they are necessary to fill or not.

3- “Verification”
We are supposed to fill this sheet with some overall information of the project. The project name, address, construction year, number of dwelling, interior temperature, enclosed volume, number of occupants, building type and utilisation pattern for internal gains.
The main issue once again also in this section is whatever we should specifying the building as. Building type is as we know a “residential” but for internal gains, we have to choice between dwelling, assisted living or other. We have decided here to see if we can, at the end, get a verification that fulfils for all these three cases. Since our building is a mixed of all these three cases.

4- “Areas”
We have filled this sheet with all the building’s exterior surfaces and calculated manually “Treated Floor Areas” or heated floor areas according to Norwegian standards. This means all the interior areas within the exterior walls (BRA) and on top floor, because of the lack of full height in the entire floor areas, we calculated the areas which are covered by 1.9 m of the height and added 60 cm on each side.
Walls and roofs have been calculated based on exterior measurements. And floor on ground and the basements floor and walls have been separated in different places and specified as areas towards ground and not ambient.
We have also chosen not to divide the areas in different walls but for example to add all the south facing walls into one place in the sheet.



5- “U-List”
This is the sheet that sums up all the inputted information we have added in next sheet, “U-Values”

6- “U-Values”
This sheet is one of the most important sheets where we have specified which kind of insulation or other layers exterior walls, floor on ground and roof containing. We have also added an extra U-value for parts of the ground floor which is surrounded by existing concrete wall in additional to the new exterior wall. As we can see all the u-values are kept under the Passive House Standard and are well insulated.

7- “Ground”
There are no examinations of the ground in Rotvoll area so it has been difficult to say for sure what kind of soil and in which level the ground water is. We have filled this sheet with many doubts and insecurity. But we know that floor is mostly on ground and basement depth is 3 meter. Our suggestion here is basically taking out the existing concrete slab on ground and crake it and put it back and builds up all new floors with insulation and thermal mass on top of it.

8- “Windows”

This is second important sheet, according to passive thermal control. Here we have filled with quantity, geographical direction, horizontal angel of windows and the size of windows. We have once again added all the windows in every each wall together to simplify our calculation.

9- "WinType"
This is the sheet we need to fill with the specifications from the manufactory that are producing the windows we have chosen. We are using Nordan Tech 0.7 windows, since we are decided to use Norwegian producers for our building elements. We were no able to find the g-value of the windows and set it to be 0.5 which is under the limit of the most of the other windows. G-value is very important to be as high as possible since it decides the admittance of heat flow into the building. We have also filled the specification of the frame in this sheet and the numbers which the producer had not, has been assumed to be under average.

10- "Shading"
Because of the circle form of the building there are going to be some permanent shading on some part of the building, which are specified in this sheet.

11- "Ventilation"
The ventilation sheet takes into account the most important rooms for ventilation, quantity of supply air, the placement of the ventilation unit (inside the envelope), and also the specifications of the chosen ventilation unit.
Since there are plenty of different ventilation unit, we are not able to choose one type and assume that the chosen unit is actually going to be used in the building. Therefore we have filled with average numbers that we think most of the unit close to. But heat recovery function is a must and an efficiency of 88% should be easy to reach and find. Another thing is the air supply duct and exhaust duct and its length which is in our case very short and close to ventilation unit.

12- "Annual Heat Demand"
This sheet is calculated the heat demand based on the information we have filled in on the other sheets. Clear room height is important number and it is given here, 2,5 m.

13- "Monthly Method"
In this sheet we can see a graph that shows us how much specific losses and gains we have.

14- "Heating load"
Here we can see the calculation for nominal heat load based on max transmission + max ventilation and minus minimum solar and internal gains.

15- "Summer"
Here we can specify the conditions of summer periods. We have chosen to mix-construction weight, because of some existing concrete walls and set an overheating limit to 25 degrees. I have also decided to only use manual window cross ventilation at night. More ventilation for summer period is given I SuummerVent sheet. We can also see if frequency of overheating is over the limit of 25 degrees, which is 0%. This means we do not need to specify more in the Summvent sheet about additional summer ventilation. Also "Cooling" and "Cooling unit" sheets are not important to fill, based on the results we have so far.

16- “Shading-S”
We can add more shading in form of temporary shading in the summers. We have decided to shade south facing windows by 90% and west and east by 50% and north with no shading.

17- “DHW + Distribution”
More specific information is needed to calculate the energy system losses from water pipes and storage. Basically we need to fill the range of the pipelines and how well insulated they are. Also losses from storage tank are important to fill in. and if some of the pipes and storage tank in placed in the colder unheated areas.

18- “SolarDHW”
We have solar collectors on our design building and in this sheet we need to write more about placement in case of shadings, type of the solar collector (using the standard flat plane collector) and type of the storage tank. It was very difficult to find any system losses from the tanks on marked and they are having different ways/measurements for these numbers. Therefor we have used the average numbers that are provided in the sheet. We can also see a graph at the end of the sheet showing how much DHW is going to be covered by the solar collectors.

19- “Electricity”, “Electricity Non-Dom” and “Aux Electricity”
These sheets are taking into account the electric equipments that are going to be used in the building which is very difficult to specify. That is why we have filled in these sheets with our best guesses.

20- “PE Value”
Primary energy values are based on what kind of heating energy source we are decided for in our building. Which are District Heating and the fractions for DHW and space heating demand is set to 100%.

21- “District Heating”
In this sheet we are supposed to give a fraction for passive heating of the building because of the solar radiations. With no further calculation we decide to set this number at the lowest possible to be on the most conservative side.
There are also many types of primary energy factor for DH, which is selected in drop box as “natural gas” and also 70% covered with combined heat and power, CHP.

22- “Climate Data”
In this sheet we are selected Region climate as “Europe-N” and regional climate “Trondheim”. This is also one of the most important sheets which play a major roll for accurate calculation for heat losses, ventilation conditions, and other that depends on what kind of climate we are in.

23- Other sheets
These are either the sheets that contain additional facilities/services that we don’t have or they are summarizing the results.
The PHPP file is attached to the report.

24- Results

As we can see in attaché PHPP file, the building is verified for both Dwelling, Assisted living and other building types, which is very good result for our building since it has a very mix usage functionality.

D. Commissioning and monitoring plan

Solar DHW

Solar collector: www.velux.no
Provider: http://www.osohotwater.co.uk/commercial-products/maxi-buffer.html
We choose Velux standard flat plate solar collector (U12 and S08). The covered area of 44 m^2 will supply the 15% of the DHW production. The remaining 85% will be provided by district heating.
The total water storage volume is 2800 l, obtained with four parallel fitted, OSO Maxi Buffer 17RB, of 700 liter each.

The interrelated achievement of owner, architect and engineer project requirements has to be ensured. All building systems have to perform interactively and meet the owner's operational needs. A monitoring plan has to be followed in the ongoing process of planning, implementation, communication, and follow-up.
These are the requirements that have to be met:

	Walls	U ≤ 0.10 W/m²K
	Exterior to ambient	U = 0.099 W/m²K
	Exterior to ground	U = 0.097 W/m²K
	Roof	U = 0.1 W/m²K
	Floor	U = 0.099 W/m²K
	Windows	
	Glazing	U = 0.70 W/m²K
	Frame	U = 0.70 W/m²K
	g-value	0.50
	Shading	
	South façade	90%
	West, East facades	50%
	District heating	22.2 kWh/ m²a
	Heat recovery unit efficiency	88%
	Solar DHW fraction	15%
	Electricity demand for appliances	14.4 kWh/ m²a

1- Construction
The energy performance according to PHPP and NS3031 is fulfilled based on lowest possible or no thermal bridges in building joints and elements which is very important to prevent in passive houses. This is the reason why it is important in construction work provided by a contractor that has passive house certification or if building element are

prefabricated it should be built by a manufactory with necessary certification to provide best possible building construction joint with no thermal bridges.
The building should also be pressure tested to be sure of the air tightness of the building is under the limit for Passive house standard. “The Passive House Standard demands a minimum tested airtightness level of maximum 0.6 ach @ 50 Pa, both for under pressure and overpressure, during the blower door test.”
This pressure test should be done as soon as possible after all the construction and building elements are built and fully operative. This is important in order to fix the unexpected uncovered errors/holes.

2- Operation
Improved comfort and air quality in the building is basically based on maintaining the HVAC system and right usage of all the operating facilities. The building is going to be automatically seasonal operated but inhabitant can change the operation of these services if other rules are kept. For example there should not be any open windows during the heating operation hours, since this will cost a lot of unnecessary energy losses through windows and doors.

3- Ventilation
Ventilation in the summer period (June, July, and August) should be provided through cross ventilation and Mechanical ventilation is not necessary and should not be operative. According to calculation on PHPP, there are no overheating possibilities and no need for any active ventilation systems in the summer months.
Winter period (October, November December, January, February and March) it should not be any ventilation through the windows and doors, since we are in heating months and it requires maximum airtightness and minimum heat losses. It is also very important to remember that all exhaust air will be leaded through a heat recovery unit and will be recovered be HVAC system. And by opening windows this useful energy will be lost and the efficiency of the HVAC system will drop.

4- Heating
Heating periods of a year is set from October until March with max 30 days variation of the heating months. The heating should not take place outside of heating months. The building has its own passive heating strategies that is calculated and documented to fulfil the requirements for summer months of a year and may be more (depends on seasonal variation). Unheated areas should be kept separate from the heating areas to prevent heat losses.

5- Lighting
The building is designed to archive best possible natural lighting conditions in the common areas which are operative on daytime of a day. Thanks to the atrium in the middle of the building where people are gathering most of the time. Also all the south facing windows are large enough to keep the lighting requirements in the daytime. East and west windows are very tall vertically shaped to let in the low sun radiation coming from these directions.
In the night time we need artificial light and they should be automatically operative with move-sensors that turn the light on and off without any need for users behaviour or misbehaviours. This is only for common areas and in Private areas there should be manually adjustable lights.

It is recommended to not use any inefficient lights and rather use LEDs (light-emitting diode) which have lower energy consumption and longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability.

6- Shading
There is calculated with some permanent shading overhangs on south facing windows and will let in the winter sun and shade for the summer sun. These overhang shadings are supposed to shade until 90% of sun radiations coming from south. These overhang shadings are in combination with some traditional aluminium rollers shadings which is placed in the interior. We have also these interior shadings on east and west facing windows that can be used by users if it is needed.

E. Norwegian products and materials

As we have already mentioned, our main goal is to get all the products and material from Norwegian marked and under we have list of all these products and materials.

Product	***Producer***	***Type***
Solar collector	Velux	U12 and S08
Photovoltaic	Sharp	NU-U235F1
Windows	Nordan	Tech 0.7
Door	Nordan	Tech 0.7
Skylight	Velux	GPU/GPL
Water tank	OSO	Maxi buffer
Material	***Manufactory***	***Type***
Wall/roof Insulation	Glava	EXTREM 33 PLATE
Floor Insulation	Glava	EPS S 150
Vapor barrier	Isola	SD5 Dampbrems
Wind barrier	Isola	Soft Vindsperre

F. Final conclusion

The project is a very complex in many different ways. First of all, we are dealing with a refurbishment of an existing building or closer a barn. And not to forget the building is preserved by Norwegian preservation authorities. This last piece of information gives us many limitations in design process for the architect. But on the other hand, the existing shape of the building is a very compact form that is a major advantage if the new building is going to fulfil the passive house requirements or even better. In based on these information, we started our design process and designed a new building with a good that both keeps the existing shape, integrate firstly passive strategies and secondary active strategies and facilities to cover the rest of the total energy demand.

We have double skin façade, thermal mass, passive and cross ventilation (in the summer periods), good access to natural light (mainly in the common areas which is operating during days), HVAC system with optimized preheated air from DSF and heat recovery,

solar collector to cover DHW, Photovoltaic panels integrated on roof with a good balance with the overall elevation design and at last but not least a reliable heating source that covers rest of the heating demand. All these facilities and strategies are carefully designed and are planned to operate.
We have also tried to integrate the PV modules, solar collector and double skin façade in the building a way that it looks like one complete building unit. This integration strategy in the design process resulted in having less PV areas and less power production.

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