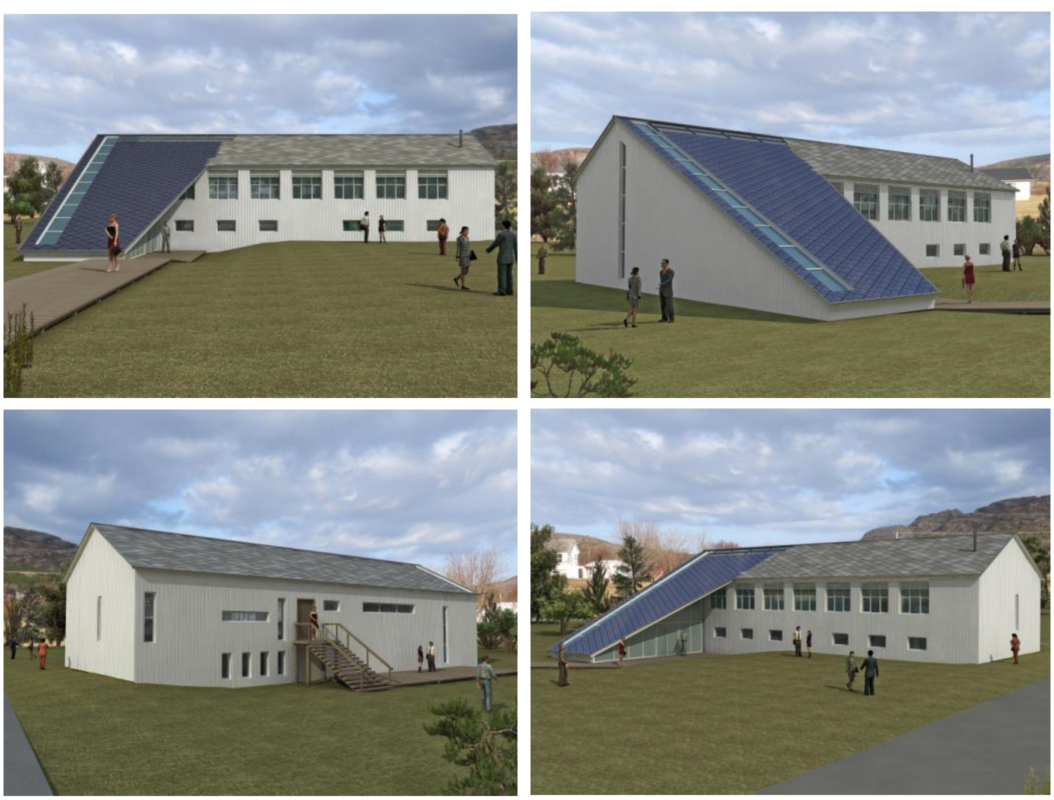
LINESØYA PASSIVE HOUSE

Assignment 3 Report

Integrated Energy Design Course

Group 6



Introduction

The aim of the design team was to renovate the Linesøya School building into an environmental building with passive house standard. The report is the output of the final detailing stage of the design, documenting the changes in the Energy Budget and the achievement of the project goals set in the preliminary phase. The report includes the final design performance assessment by using PHPP tool and operational strategies have been explained in the process of building performance simulation.

One of the main objectives of the design was the development of the functional program that will provide all the required functions for both private use and for the transformation of the building into the demonstration centre of the environmental solutions. The zoning considerations started on the site plan scale by clear division of private and public areas, followed up by the spatial arrangement of the original building and addition of a new volume. The visitors enter the extension which serves both circulation and exhibition purposes from the basement level. The basement of the original building is fully functional public zone providing conference facility and the mechanical room which is also used for demonstration. The ground floor is divided into the public zone – cafe and the residence for the owners, which has a private entrance from the North.

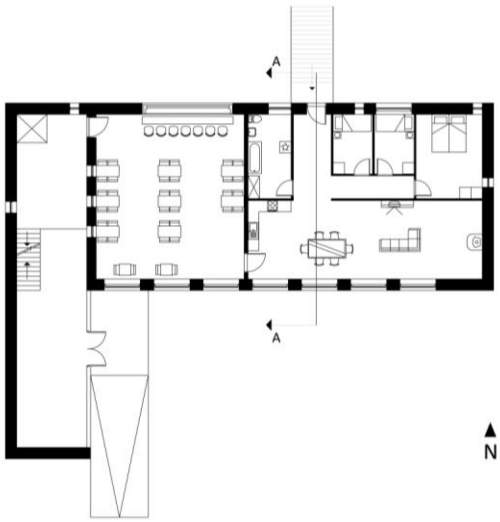


Figure 1: Ground floor plan

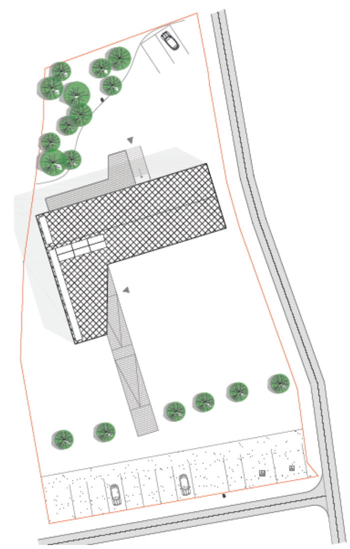


Figure 3: Site plan

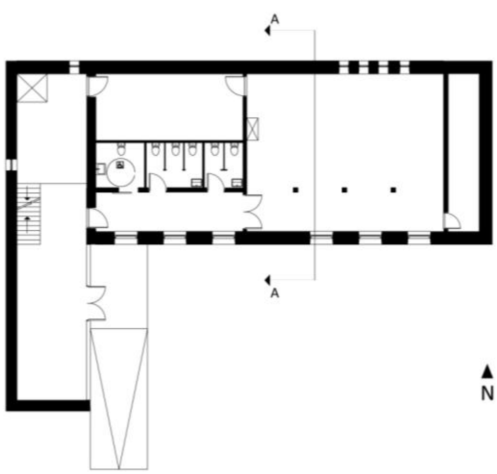


Figure 2: Basement floor plan

The final design concept described below encompasses the functional as well as energy and architectural considerations.

Design concept

- Adding a buffer zone on the West side of the original building for energy preservation
- Installing active solar systems on the roof of the extension for energy production
- Demonstrating energy production by bringing down the roof slope of the extension to the level where the energy production will be visible and accessible to the visitors
- Clear visual distinction between original energy receiving volume and new energy producing volume

Project goals

- Finding out a visible and exciting way to demonstrate energy production
- Universal design
- Finding out the true value of annual energy use: Annual Energy + Embodied Energy (means consideration about material choices are carefully analyzed)[1]

Renovation concept

- Insulating the entire building envelope
- Airtight from inner side of the insulation layer, airtight layers around the entire building envelope
- Thermal bridges should be prevented by adding insulation between the joints and airtight layer should also go through the back side of the opening frame

Renovation method

The "hat method" suggested by ISOVER can be used in this case. By using hat method, insulation can be added around the building envelope and its surrounding ground.

Advantages:

This method provides easier refurbishment by only concentrating on the building external work; living area will not be reduced; the insulation located in the surrounding ground can help reduce the heat losses from the basement floor since the temperature difference has been reduced

Disadvantages:

There maybe be problems if the rain water cannot be drained away and remaining on top of the insulation layer; the width of the surrounding ground insulation depends on the local condition (the depth of frost layer), sometimes up to 6 meter; whether it is worth to dig the whole site 6 meter around the building to add insulation or it is better just to demolish the old basement floor and add insulation from outside.

[1] Analysis of material and construction is stated in the client posters, starting from P3 till P5.

Final design performance assessment in PHPP

In Linesøya passive house project, the building contains following zones: residence + culture + other. There are no regulations in NS3700 that state about this type of multi-purpose passive house. So in the assignment 2 (energy budget stage), we have calculated the energy use for residence and cultural part separately by assigning different operational schedules, internal gains. At last the result has been compared with the residential passive house standard, because we considered the residential purpose as the main function of the building.

Verification + climate data

- Climate: Oslo
- Building type: residential
- Number of occupants: 14, calculated according to German standard – 35m^2/person.
- Enclosed volume (V_e): 1827, 8m^3.
  Caution: this column is different than V_v (effective air volume) which has been used for ventilation calculation.

Area

Treated floor area:

"Passive House Planning Package 2007" P45 states: *In PHPP only rooms inside the thermal envelope are taken into account...*

Sequence of finding out the treated floor area in this project is shown as follows:

1. Defining thermal envelope: Green thermal envelope (existing) and yellow thermal envelope (extension).
2. Green thermal envelope:
   1) Residence: 101m^2
   2) Cafe: 66m^2
   3) Conference: 86m^2
   4) Other: 160 m^2 (the part with height lower than 2m height counted 50%)
   TFA = 413m^2
3. Yellow thermal envelope:
   1) Exhibition + Entrance: 82m^2 (the part with height lower than 2m height counted 50%)
   2) Exhibition second floor:
4. Total TFA = 413+82=495m^2

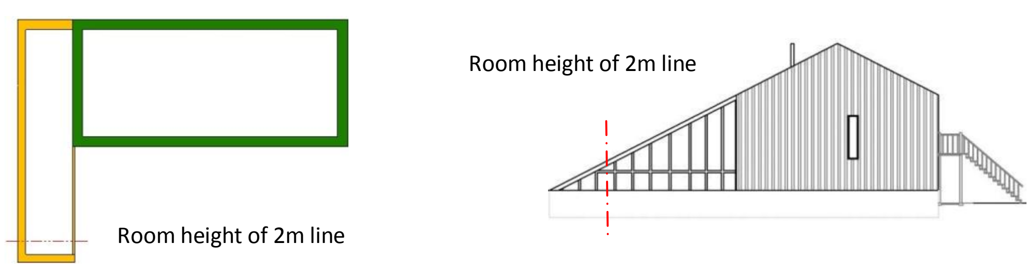


Figure 4: Defining thermal envelope and room with height at least 2m.

Difference	1) *In PHPP, the treated floor area (TFA) is required (calculation method as stated above).* 2) *In NS3700, the heated floor area is required. The energy budget in assignment 2 is calculated according to NS3700 with heated floor area of 330m^2. The result has been compared with residential passive house requirement.*
Doubt	1) *Since the treated floor area calculation is according to the residential building requirement, the non-living area should be found in "Wohnflächenverordnung". But the cultural part of this building does not belong to the residential building. It should count as non-residential building itself.* 2) *We assumed at the beginning, the main function of the building served residential purpose, the cultural part is considered as the non-living area within the residential building (even though it will be the violation of the German standard).* *If we count the cultural part as non-residential building, according to "Passive House Planning Package 2007", the TFA will be slightly more than 400m^2. There will be 54m^2 more than the result calculated above.* 3) *Decision of TFA has been made: 495m^2.*

U-values for building elements:

For the details of the construction of building elements stated in Table 1, please check drawing D1, D2 and D3.

Compilation of the building elements calculated in the U-Values worksheet and other construction types from databases.

	Type		
Assembly No.	Assembly Description	Total Thickness	U-Value
		m	W/(m^{2}K)
1	Exterior wall (Ground floor)	0,668	0,08
2	Roof	0,533	0,09
3	Basement floor	0,493	0,11
4			
5	Basement wall	0,761	0,09

Table 1: U-list, taken from PHPP tool.

Thermal bridges:

In the passive house, architectural solutions with the lowest possible thermal bridge heat loss coefficients are preferred. "Passive House Planning Package 2007" P50 states: *When using "thermal bridge-free construction" there is no need to perform further calculation.*

Heat loss via the ground:

Several data are missing, e.g.: ground water correction. We cannot calculate the heat loss via the ground. But the "Passive House Planning Package 2007" P56 states: *if the ground worksheet is not filled in, a standard reduction factor determined in the climate data worksheet is used in annual heating demand worksheet.* The ground reduction factor used here is: 0,533. Since there is horizontal laying insulation around the building, the ground temperature should be higher than normal situation. In the heat loss via the ground work sheet, monthly average ground temperatures (PHPP tool, row 82-85) have been provided by Oslo data and the temperatures are considered favorable for this case.

Windows

Window direction:

According to “Passive House Planning Package 2007” P64, North is chosen as the reference direction and deviation from North has to be filled in the worksheet.

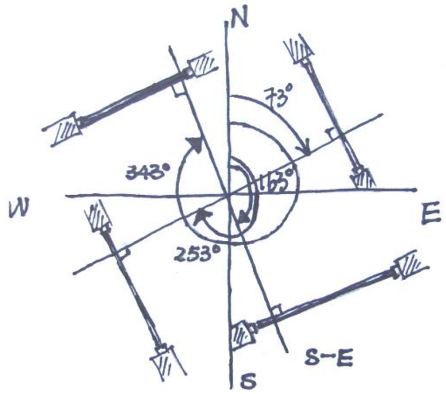


Figure 5: Linesøya building, angular deviation, from the North-south line.

Sketch in Figure 5 indicates the right orientation of the building and windows deviation from the North-south line:

- South window:163°
- North window: 343°
- West window: 253°
- East window: 73°

Window type:

There are various window types available in the PHPP data and the choices are made carefully. We have tried several types of glazing by considering the solar gain, and several window frames by considering the thermal bridges and the sizes which can influence the solar gain and shading. Triple glazing with 28 Low-E 0.51 N 52 - GUARDIAN Flachglas type and argon gas fill in and standard PU on wood as window frame has been chosen for further calculation. In table 2, it indicates the average U-value for all windows is 0,65W/m^{2}K.

Climate:	N - Oslo										
Window Area Orientation	Global Radiation (Cardinal Points)	Shading	Dirt	Non-Perpendicular Incident Radiation	Glazing Fraction	g-Value	Reduction Factor for Solar Radiation	Window Area	Window U-Value	Glazing Area	Average Global Radiation
maximum:	kWh/(m²a)	0,75	0,95	0,85				m²	W/(m²K)	m²	kWh/(m²a)
North	63	0,82	0,95	0,85	0,372	0,52	0,25	9,10	0,77	3,4	65
East	180	0,93	0,95	0,85	0,776	0,52	0,58	33,00	0,60	25,6	132
South	432	0,94	0,95	0,85	0,672	0,52	0,51	30,67	0,65	20,6	418
West	182	0,61	0,95	0,85	0,436	0,52	0,21	3,00	0,77	1,3	242
Horizontal	233	0,75	0,95	0,85	0,000	0,00	0,00	0,00	0,00	0,0	233
		Total or Average Value for All Windows.				0,52	0,50	75,77	0,65	50,9	

Table 2: Average U-value of the windows: 0,65W/m^{2}K.

Shading:

Shading factor shows the percentage of solar radiation that reaches the window surfaces of 4 zones: Cafe, Residence, Conference and Extension.

According to “Passive House Planning Package 2007” P99, the facades of the Passive house should be mainly kept un-shaded. This guideline for utilization of solar gains was followed as closely as possible in the design. As can be seen from the calculations all the windows on the south façade are practically not shaded, the only exception is the first window of the Café zone, see Figure 3.

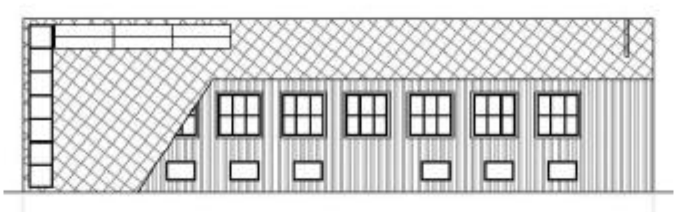


Figure 6: South elevation

Cafe: shading factor determined by

- Window reveal
- Window header and roof overhang

Residence: shading factor determined by

- Window reveal
- Window header (the length of the roof overhang insignificant for calculation)

Conference: shading factor determined by

- Window reveal
- Window header

Extension: shading factor determined by

- Window header
- Roof overhang

Ventilation

Main considerations for sizing the ventilation system: according to “Passive House Planning Package 2007” P81:

- Airflow volume should not be too high because of the risk of the air being to dry.
- The system should be optimized to the most frequently occurring air flow change rate not for the maximum rate. Average air flow rate shouldn’t be smaller than 0.3 (1/h).

Certified heat recovery unit used: Campus 500 DC – Paul with efficiency 83%

Since the building has been identified as residential building, the operational hours for the ventilation system is 24 hours. And in this case, room ventilation volume is 1238m^3. According to the German standard, 30m^3/ph (supply air per person) is typical value for dwellings.

Main outputs:

- Average airflow rate: 371m^3/h
- Average air change rate: 0,3/h
- Infiltration air change rate: $n_{v, res}$=0.035/h (for annual heating demand).

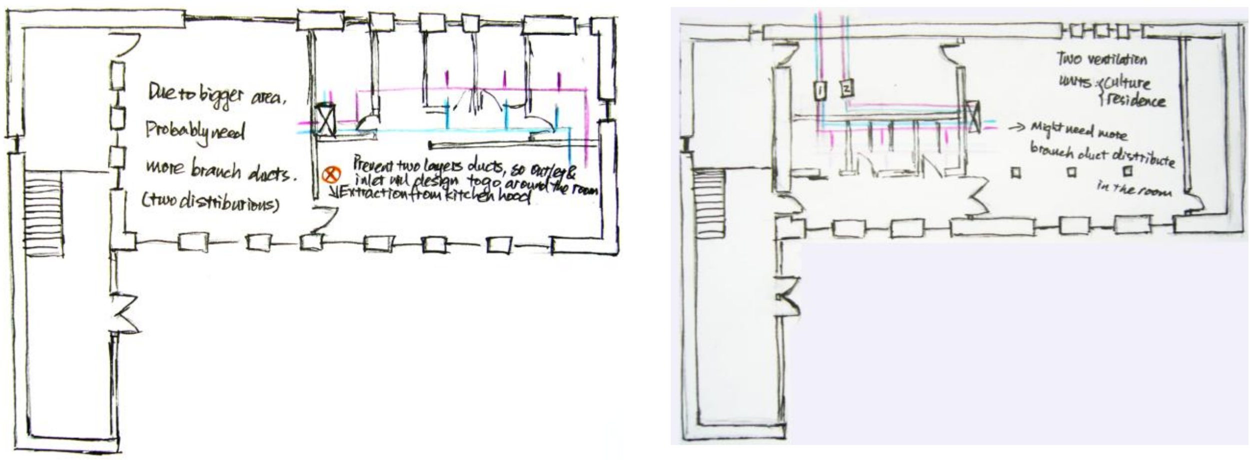


Figure7: Rough sketches for the ventilation ducts distribution in the building (ground floor plan on left, basement plan on right).

Annual heat demand calculation

The annual heat demand in this case is 15kWh/m^2a. So the house has fulfilled the passive house standard.

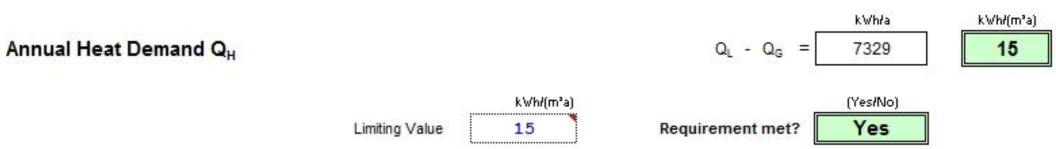


Figure 8: Annual heat demand taken from PHPP Annual heat demand worksheet.

The project already fulfilled the annual heat demand, heating load calculation in the PHPP specific space heating load is not necessary to be analyzed. If there is a slight difference between specific space heating load and heating load transportable by supply air, a simply portable heating device, e.g. electricity radiator can be used.

Summer calculations

Summer ventilation:

In summer period, the natural ventilation strategy has been provided for the building. In the residence, single side ventilation is provided while the fraction of opening duration is assumed to be 50% that means the windows will be open for 12 hours/day. In cafe, in combination with thermal mass (concrete), night purge ventilation is provided while the fraction of opening during is assumed to be the whole night (100%). PHPP indicates that in this case, the frequency of overheating is 0.0% at the overheating limit of 25°.

Summer shading:

Venetian blinds are used for exterior shading device. And it is assumed that the temporary shading reduction factor is 20% means 80% of the windows are shaded.

DHW + Distribution calculation

Heat distribution and DHW system:

There will be no supply of space heating by DHW system.

Circulation pipes (main pipes) running in the shaft is 10m in length (forward + return). The distribution pipes length is 20m (forward + return). Total demand for DHW is 10790kwh/a. Specific demand will not be used here when comparing the demand calculated from energy budget (Assignment 2 report P17) since the method of square meter counting is different. Total demand for DHW in energy budget is 8636kwh/a and difference is 2154kwh/a.

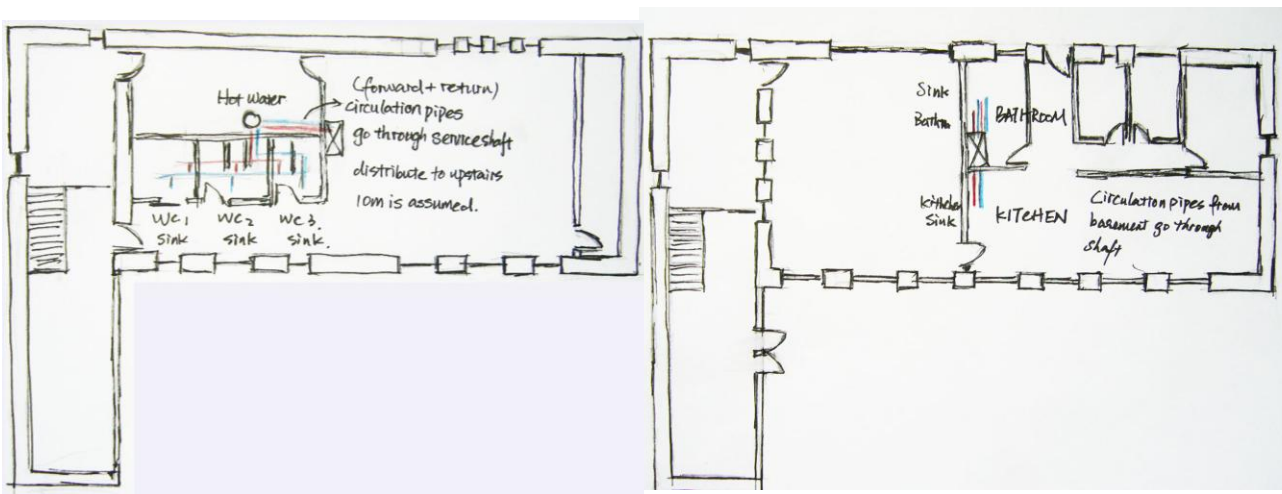


Figure 9: Distribution of hot water distribution in the building (basement on the left, ground floor on the right).

Hot water provided by solar:

In the design phase, we put 7m^2 for the solar thermal collector. Heat pump can be used for covering the rest of DHW demand. And total electricity demand for heat pump is estimated in PHPP PE value worksheet.

Electricity

All the appliances used in the project will run by electricity, which can be defined in worksheet electricity in PHPP. The electricity production from PV is calculated in PVGIS: 7580kWh/a (inclination 27). This figure can be used in PHPP PE value worksheet in order to get the primary energy value conservation by solar electricity: 30,6kWh/m^{2}a with CO_2 emissions avoided due to solar electricity.

Primary energy value

In this project, total primary energy is 52,4kWh/m^{2}a and total emissions CO_2 – Equivalent is 13,2kg/m^{2}a, see table 3. Heat pump is also chosen to use in this case for covering the rest of the fraction of DHW demand. Calculation of electricity used for heat pump is also carried out in this worksheet in PHPP. The total electricity demand for heat pump is 6.6kWh/m^{2}a.

Heating, Cooling, DHW, Auxiliary and Household Electricity		19,4	52,4	13,2
Total PE Value	52,4	kWh/(m²a)		
Total Emissions CO_2-Equivalent	13,2	kg/(m²a)		(Yes/No)
Primary Energy Requirement		120	kWh/(m²a)	Yes

Table 3: Total PE and total emissions value

Passive Quality:

- Efficient thermal zones: zoning in areas according to the same comfort requirements, same time of occupancy and activity level, passive solar heating avoided in the areas with the high internal gains, used in the areas with the high heating demand
- Temperature control
- Passive solar gain: use of the thermal mass in the Café zone
- Solar shading: protection from the sun by venetian blinds on the South windows due to glare and overheating.
- Natural ventilation: cross ventilation, single sided, night purge ventilation
- Daylight: the height/ depth relationship of the room, choice of glazing, placement and size of the windows.

Active Quality:

- Heat recovery ventilation system
- Active solar: solar thermal collector, PV

Conclusion

The design team pursued the main goal of choosing the most promising concept from the energy performance view point. The most promising concept with the heating demand of 15kWh/m^{2}a and heating, cooling total demand of 16kWh/m^{2}a was identified by the improvement of the performance of the building by following the renovation concept and operational instructions state in the PHPP assessment process above.

Renewable system is also sized in the PHPP assessment; PV: 100m^2 and solar thermal collectors 7m^2. Heat pump is also chosen to use in this case for covering the rest fraction of DHW demand. Total primary energy demand of this project is 52.4kWh/m^{2}a. The passive house standard has been fulfilled, see table 4.

Specific Demands with Reference to the Treated Floor Area				
Treated Floor Area:	495,0	m^2		
	Applied:	Annual Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	15	kWh/(m^{2}a)	15 kWh/(m^{2}a)	Yes
Pressurization Test Result:	0,5	h^{-1}	0,6 h^{-1}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):		kWh/(m^{2}a)	120 kWh/(m^{2}a)	
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):		kWh/(m^{2}a)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	31	kWh/(m^{2}a)		
Heating Load:	10	W/m^2		
Frequency of Overheating:		%	over 25 °C	
Specific Useful Cooling Energy Demand:	0	kWh/(m^{2}a)	15 kWh/(m^{2}a)	Yes
Cooling Load:	1	W/m^2		

Table 4: Specific space heating demand