Linesøya passive house

Assignment 3

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The target for this project is to refurbish an old school building to a passive house standard. Part of the building is planned to be an apartment, and part of it a kafe and exhibition of sustainable issues mostly building related. Because of this multiple use, specifications from both NS 3700 and Prosjektrapport 42 from SINTEF byggforsk.

Here are some of the requirements in more detail:

Category	Requirements	Source
Requirements for indoor climate:		
indoor air quality	Class II: 0,42 l/s* m^2 = 1,5 m^3/hr* m^2 or 7l/s*person= 25,2m^3/hr*person	(NS 15251 tab B.5)
noise	Livingroom 25-40 db , Bedroom 20-35 db	(NS 15251 tab E.1)
light	500 lx	(NS 15251)
themperature	ppm/ppd class II <10% dissatisfied	(see graph in "Enøk i bygninger")
Requirements for building specifications:		
U-values (average)	Floor: <0,15 W/(m^2K) Roof: <0,13 W/(m^2K) Wall: <0,15 W/(m^2K) Window/door: <0,8 W/(m^2K)	NS 3700 tab 5.
Linear thermal transmittance (thermal bridges)	0,03 W/ m^2K	NS 3700 tab 5.
Temperature efficiency heat exchanger	>80%	NS 3700 tab 5.
SFP-factor	<1,5 kW/(m^3/s)	NS 3700 tab 5.
Leakage number av 50 Pa,n50	<0,6 h^{-1}	NS 3700 tab 5.
Heat loss, H”	A_{fl} >250m2: 0,5 W/(m^2K)	NS3700 tab.2

Another important issue is to make sure that the building meets the requirements set by the law. In Norway that means that the TEK 2010 and the corresponding standards (NS 3031, NS 15251 etc) have to be met.

Changes during the design process

Woodchip-burner / pelletsboiler

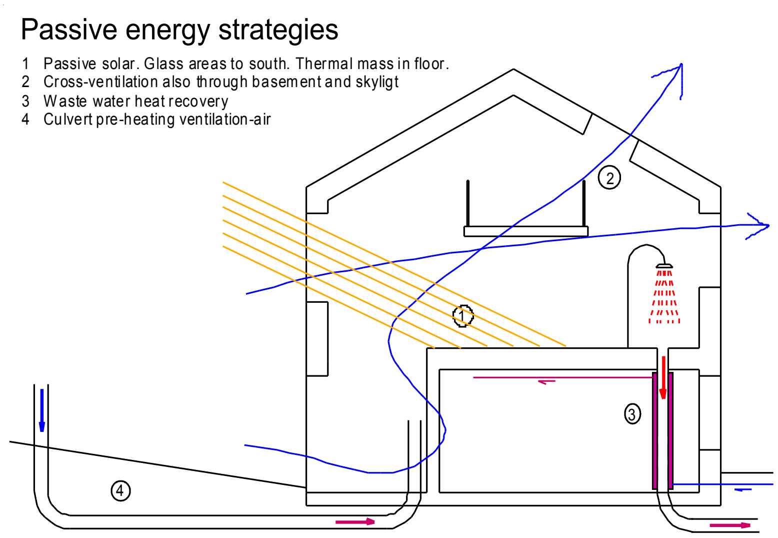
In the start we were planning to use a woodchip-burner because the wood-chips can be produced locally on the island (and less energy is used to produce chips than pellets). We found out however, that the burners available are 20kW and bigger, and that is much too big for a passive house. Also the storage of the chips, and the automatic systems for feeding wood chips take a lot of space.

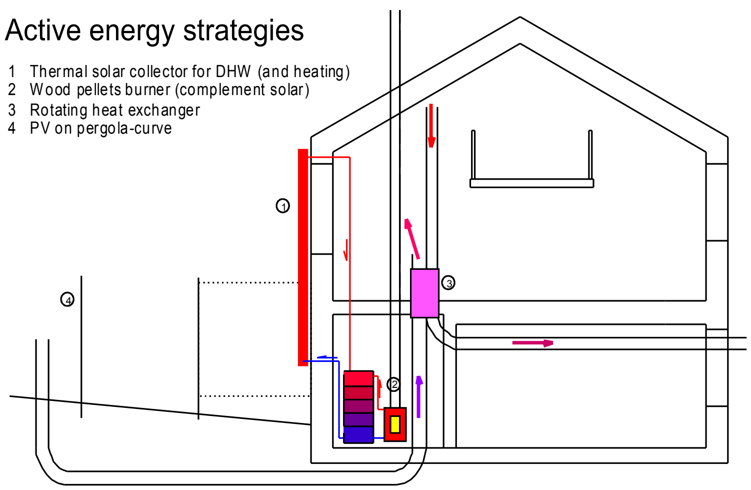
Because of this we decided to use a wood pellet boiler instead. Pellets contain almost 4 times as much energy / volume, so it is possible to get pellets for several years supply on one truck, and thus the extra energy needed for longer transport is very little.

Annual pellets-demand:
Energy demand from pellets: 10 000 kWh
Efficiency 80% means we need pellets containing 12500 kWh.
3200 kWh / m3 pellets, means we need 3,9 m3 pellets pr. year.

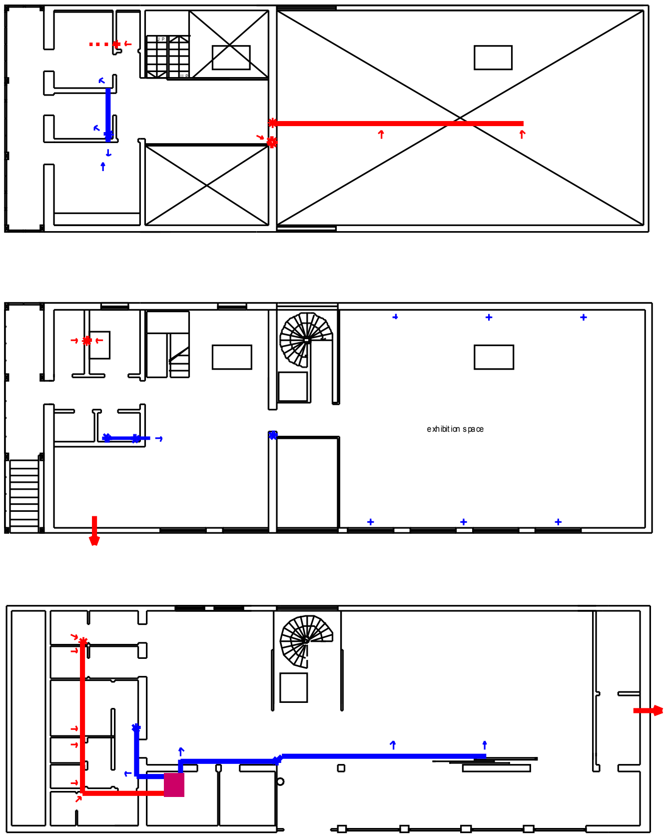
This can easily be stored in the technical room.

External shading
At first we assumed that with so many big windows on the south we needed some external shading to avoid overheating, and designed a fixed shelf.
Calculations in Simien showed that this was not necessary so we ended up having only internal shading.





Balanced ventilation



Energy-calculations in Simien.

Requirements from NS 3700: (and Prosjektrapport 42).

	Calculated	Required maximum
-Heating demand:	14,7 kWh/m2	15 kWh/m2
-Overall heat loss factor	0.36 W/m2*K	0,5 W/m2'*K
-CO2-emission	16,3 kg/m2	25 kg/m2

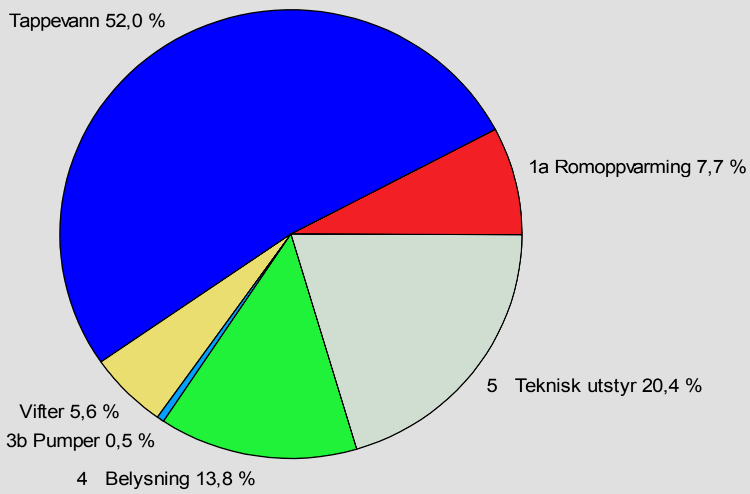
-At least halv of the energy used for heating and DHW has to come from non-fossil: In our case this is fulfilled by the biofuel alone (3558 kWh) without counting the contribution from the solar collector.

Net energy demand: 10887 kWh 86 kWh/m2

Total electricity consumption: 21700 kWh
PV on curved pergola covers 10% of this.
With PV also on south roof 45% is covered.

Annual energy budget

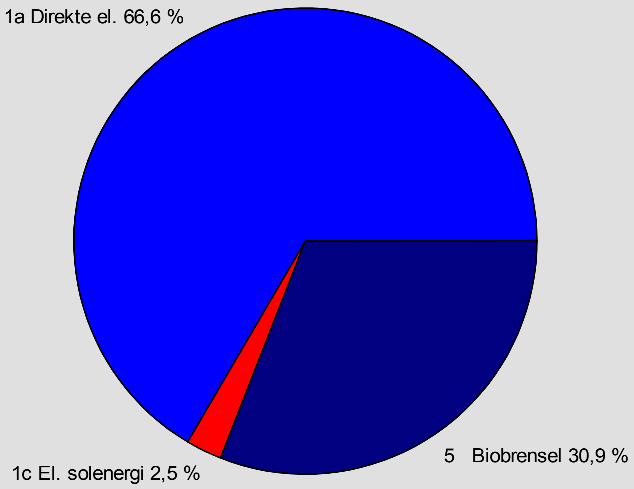
Årlig energibudsjett



1a Romoppvarming	839 kWh
1b Ventilasjonsvarme (varmebatterier)	5 kWh
2 Varmtvann (tappevann)	5658 kWh
3a Vifter	609 kWh
3b Pumper	54 kWh
4 Belysning	1505 kWh
5 Teknisk utstyr	2219 kWh
6a Romkjøling	0 kWh
6b Ventilasjonskjøling (kjølebatterier)	0 kWh
Totalt netto energibehov, sum 1-6	10887 kWh

Delivered energy:

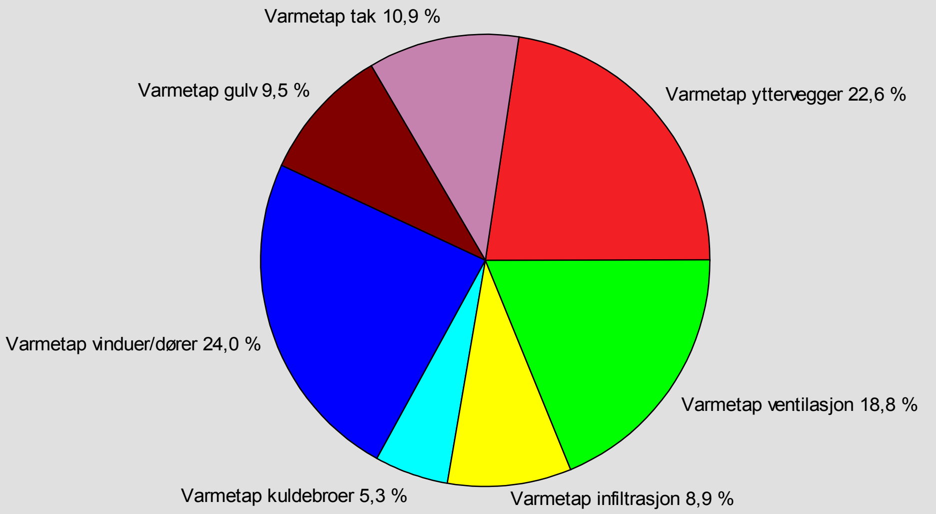
Levert energi til bygningen (beregnet)



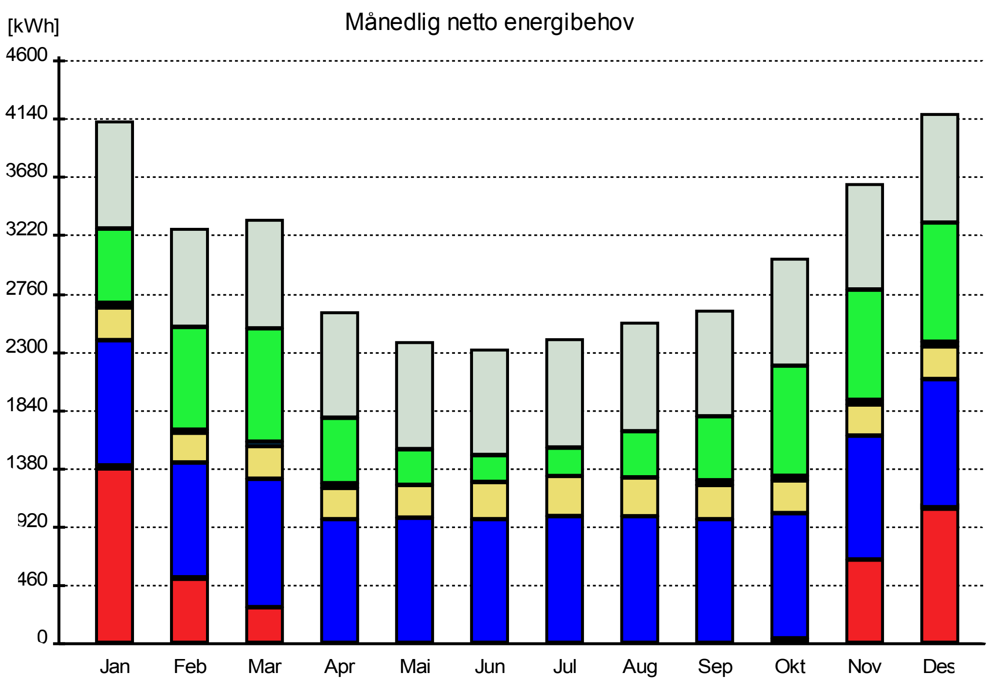
1a Direkte el.	21720 kWh
1b El. Varmepumpe	0 kWh
1c El. solenergi	813 kWh
2 Olje	0 kWh
3 Gass	0 kWh
4 Fjernvarme	0 kWh
5 Biobrensel	10091 kWh
6. Annen ()	0 kWh
Totalt levert energi, sum 1-6	32623 kWh

Thermal loss budget

Varmetapsbudsjett (varmetapstall)

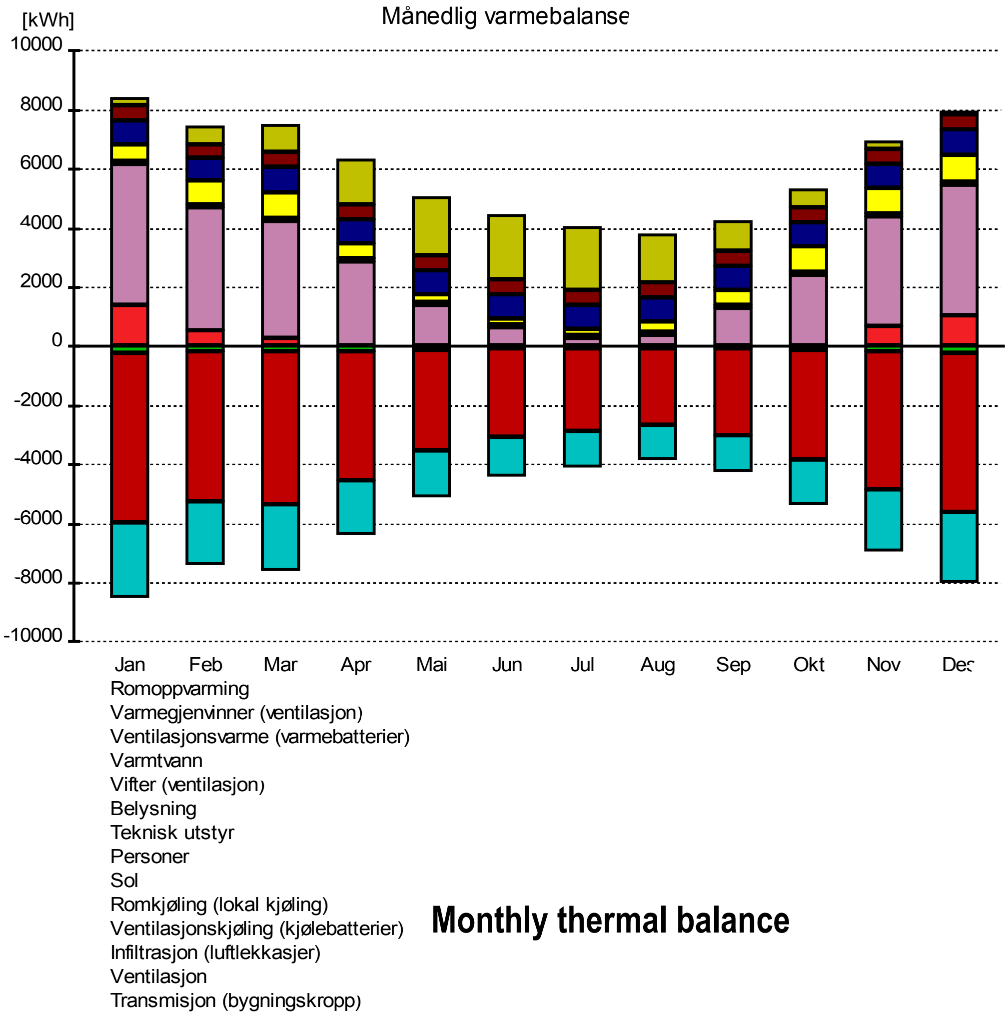


Varmetapstall yttervegger	0,10 W/m²K
Varmetapstall tak	0,05 W/m²K
Varmetapstall gulv på grunn/mot det fri	0,04 W/m²K
Varmetapstall glass/vinduer/dører	0,10 W/m²K
Varmetapstall kuldebroer	0,02 W/m²K
Varmetapstall infiltrasjon	0,04 W/m²K
Varmetapstall ventilasjon	0,08 W/m²K
Totalt varmetapstall	0,43 W/m²K



1a Romoppvarming
1b Ventilasjonsvarme
Tappevann
Vifter
3b Pumper
4 Belysning
5 Teknisk utstyr
6a Romkjøling
6b Ventilasjonskjøling

Monthly energy demand



Monthly thermal balance

Solar collector

We are planning to use vacuum pipe solar collectors “Optima” from “Ekologiska byggvaruhuset”. The pipes are rotated so they are optimized for being mounted vertically. On the wall we can fit in 5 heights of modules in 2 sets (module size: 2180x775). Each module produces roughly 700 kwh/year, ad with 10 modules this means 7000 kWh/year.

According to Simien we need about 15000 kWh from the solar collectors, but I think the demand in reality will be lower. It might however be necessary to install some solar collectors also on the curved pergola.

Follow-up plan

In general technical installations should not be built in and hidden as usual. They can be an important part of showing what a passive house is and how it works. This can be done in different ways: some things may have a glass cover. Or there are glass windows in the technical rooms, and roups with a guide can enter the room.

Airtightness:
It is very important that the building achieves good airtightness. The reason for this is to reduce the thermal loss, ensure thermal comfort and reduce the risk of moisture damage. In a windy place like Linesøya this is extra important.
To make this happen, it is important to make sure all the people taking part in the construction understand the importance of this, and have the necessary skills to do it.

The windproofing layer should consist of GU (wax-impregnated sheet rock) and a foil /paper. All seams should be well pressed or taped. Special care should be taken between the foundation and the construction above, in corners, around windows and doors and where pipes and cables enter the building.
-Recommended tape: Siga
-Around windows and doors there should be both tape and sealant.
-The doors and opening windows should preferably have double gaskets.
-The position of cables and pipes should be determined at an early stage, so that these openings can be made in a good way.
-Remember that gravel is not airtight.

When the exterior windproofing is done (before as much as possible of the insulating) an airtightness-test should be made. This is to be able to improve the envelope at an early stage if necessary.

When the envelope is completed another airtightness-test should be made, to ensure that it fulfills the passive house demand of max. 0,6 ACH at 50Pa.
If not, the contractor for that part has to make it better (specify this principle in contracts).

Moisture control (condensation):
Good airtightness on the inside of the thermal envelope is very important to avoid moisture transport and condensation in the construction. I recommend using "Isola Sd5 dampbrems", and taping the joints. Extra attention should be given around windows, doors, and where cables and pipes penetrate the envelope. In this building a difficult and important part is where the roof beams (undergurt) penetrate the envelope, special focus should be given here.
The Isola Sd5 dampbrems has an Sd-value of 5m. I recommend using "Isola soft vindsperre" with an Sd-value of only 0,025m, as the outer layer. This gives a ratio outside /inside layer of 1:200, and that is well above the recommended 1:10.

Thermal as the bridges:
-chimney: we are using a circular chimney with two layers of stainless steel with mineral wool insulation between. To decrease the thermal bridge more, there shold be added an ekstar layer of insulation and steel on the part above the roof.

On the top there should be a lid that closes automatically when the burner is not in use. This prevents cold air to circulate in the chimney.

Air supply to burner:
In a building with with good airtightness it is important to have a separate system to supply air to a burner. We are using an automatic pellets boiler, and in this case a good solution is a 100mm plastic pipe directly out from the burner room. This must be insulated to prevent condensation, and to prevent a thermal bridge when the burner is not in use.
A similiar pipe for filling pellets to storage tank should also be fitted.

Ventilation:
In order to keep the SFP low, it is important to keep the friction in the air ducts low. To achieve this:
-as short ducts as possible
-ducts with a smooth interior surface
-few bends, bends with big radius
-sufficient diameter in the ducts
The ducts should not be permanently clad in, rather use demountable channels. This makes it easier to inspect, clean or rebuild the duct systems.

The undergroud intake duct can get some condensation if used for cooling in summer, so it needs a slope of 2% to a drain. If the drain is inside the building it is easier to inspect (and also more possible to exhibit details of this system).

It is of course important to choose fans that themselves have a low SFP-factor, and a rotating heat exchanger low pressure drop.
The SFP-factor and the efficiency of the ventilation system must be measured and calculated when it is completed, to ensure that it fulfills the defined values of: 1,5 kWh /(m3/s).
If not, the contractor for that part has to make it better (specify this principle in contracts).

Cross ventilation in summer heat:
-Important that some windows can be opened on both sides on both floors, and that the roof windows can be opened.

Thermal solar collector:
-do not plant trees that give shade to the collectors.
-mounting robust enough to withstand hurricanes.

Waste water heat recovery
All the wastewater from the apartment is fed through a vertical heat exchanger unit replacing the ordinary 75mm drain pipe. This is situated in the basement (gym showers). The preheated clean water coming out of this is fed to the hotwater tank and all water outlets except the kitchen sink (it is nice to drink cold water). In other words, an extra pipe for the kitchen sink bypasses the heat recovery system.
This heat exchanger should not be covered, it exhibits the technical function of the building, and should be supplemented by signs and posters explaining what it is and what it does.
The showers in the basement are made with a special bottom containing a heat exchanger tray. The preheated clean water coming out of this is fed to the hotwater tank and the coldwater tap in the showers.

Construction and operation strategies

Construction phases and strategies:

Short summary:

- Change of micro-topography to provide quality conditions inside the house
- Minimum interventions on the structure of the existing house
- Use of prefabricated elements for additions

Changing the micro-topography of the site was one of the key elements for this project. The amphitheater in front of the public part of the building is both a gathering and a focal point. In order to allow the plants on the site to grow by the end of the building process, the soil excavation should start first. Extensions on the sides need new foundations, and also existing ones need some improvement in terms of insulation.

As the original form of the house is not changed much, work on the interior can start without disturbing other operations (such as digging of soil for new foundations). The interior work includes rearrangement of internal walls, openings in the ground floor slab and removal of the ceiling.

As the sanitary blocks (private toilets and bathroom, private kitchen, public toilets, gym showers, cafeteria kitchen and bar) are all positioned inside side extensions, they can be made as prefabricated elements and quickly assembled and joined to the main structure on site. The "solar pergola" can also be produced off-site.

Operation strategies:

Short summary:

- Functional flexibility has positive impacts on energy use
- Since the occupancy will occur in the hottest periods, there will be a lot of internal heat gains. Therefore, double height ceiling is suggested in mostly visited rooms
- Cross ventilation in hot periods
- Isolation of unused rooms in winter months. Minimum temperature inside those rooms is provided with "waste heat" from surrounding heated rooms

The house is designed to be functionally flexible, so it can quickly and easily adapt to various uses. This was achieved by an open plan layout, with possibilities of closing/opening or joining/separating certain rooms by movable elements. This approach works quite well for the energy performance as well, as it allows unused rooms to be separated from the conditioned area.

It is our assumption that the maximum use of the house will occur in summer months. The form of the house works together with wind conditions on site, ensuring that overheating does not happen. During the design stage, the team agreed that the most possible problems associated with overheating might occur in the exhibition area and the cafeteria, because of high occupancy. Therefore, it was agreed to increase the ceiling height in the exhibition space, so the warm air will rise above the occupants' level. The cafeteria is positioned in the basement (which can be considered as ground floor after micro-

topography interventions). Large glazed area on the south was originally planned for providing daylight but also provides fresh air for natural ventilation. By physically connecting the basement area with above double-height space, very favorable natural stack-effect ventilation is ensured.
Summer simulations in Simien shows that the cross ventilation is will work well, and calculates the maximum indoor air temperature to be 24,1 degrees, and the maximum operative temperature 23,6 degrees.

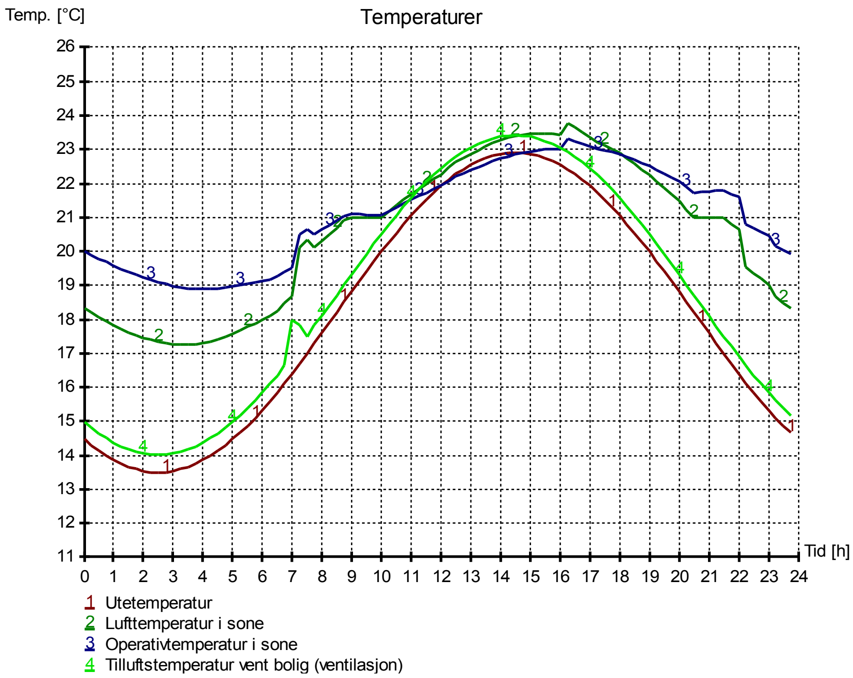
Some parts of the house will probably not operate in extreme winter periods. For example, the cafeteria is dimensioned for 60 guests. Integrating a couple of tables with the exhibition space would make sense in both economical and practical reasons. In such a case, the whole room can be closed with insulated panels and remain unheated for a certain period.

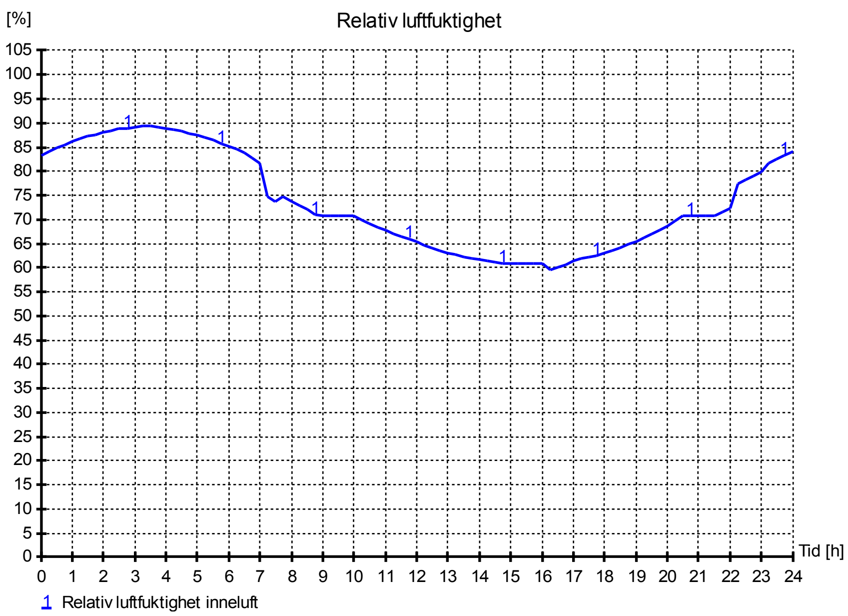
This principle of allowing the “waste heat” from surrounding areas to warm unused rooms to a minimum required temperature is used throughout the house. For example, the guest room, on the first floor of the private part, is positioned between two bedrooms. By regulating the u-values of the separating internal walls, the temperature inside the room can be remained at a certain level, even if not directly heated.

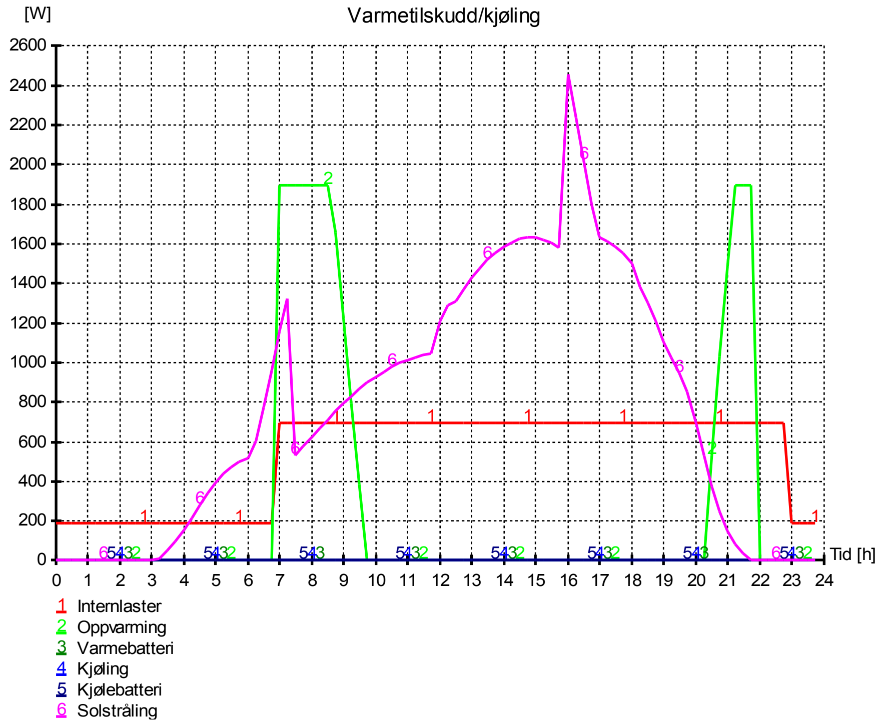
Appendix

Summersimulation for the apartment:

Sammendrag av nøkkelverdier for boligdel		
Beskrivelse	Verdi	Tidspunkt
Maks. innelufttemperatur	23,8 °C	16:15
Maks. operativ temperatur	23,3 °C	16:15
Maks. CO2 konsentrasjon	400 PPM	16:30







Inndata rom/sone	
Beskrivelse	Verdi
Oppvarmet gulvareal	126,6 m²
Oppvarmet luftvolum	377,0 m³
Normalisert kuldebroverdi	0,02 W/K/m²
Varmekapasitet møbler/interiør	4,0 Wh/m² (Middels møblert rom)
Lekkasjetall (luftskifte v. 50pa)	50,00 ach
Skjerming i terrenget	Ingen skjerming
Fasadesituasjon	Flere eksponerte fasader
Driftsdager i Januar	31
Driftsdager i Februar	28
Driftsdager i Mars	31
Driftsdager i April	30
Driftsdager i Mai	31
Driftsdager i Juni	30
Driftsdager i Juli	31
Driftsdager i August	31
Driftsdager i September	30
Driftsdager i Oktober	31
Driftsdager i November	30
Driftsdager i Desember	31

Inndata fasade/yttervegg

Beskrivelse	Verdi
Navn:	sørvegg bolig (fasade)
Totalt areal	34,0 m²
Retning (0=Nord, 180=Sør)	167°
Innv. akkumulerende sjikt	Massivtre (tykkelse over 40 mm) Varmekapasitet 12,0 Wh/m²K
Konstruksjon	48 mm dobbeltveggkonstr, 400 mm isolasjon Uverdi: 0,10 W/m²K
Utvendig absorptionskoeffisient	0,80

Inndata CAV

Beskrivelse	Verdi
Navn:	vent bolig (CAV ventilasjon)
Ventilasjonstype	Balansert ventilasjon
Driftstid	15:00 timer drift pr døgn
Luftmengde	I driftstiden: tilluft = 1.2 m³/hm², avtrekk = 1.2 m³/hm² Utenfor driftstiden: tilluft = 1.2 m³/hm², avtrekk = 1.2 m³/hm² Helg/feridag: tilluft = 1.2 m³/hm², avtrekk = 1.2 m³/hm²
Tilluftstemperatur	Min. tillufttemp: 10.0 °C Maks. tillufttemp: 18.0 °C Høy utetemp: 25.0 °C Lav utetemp: 20.0 °C
Varmebatteri	Ja Maks. kapasitet: 10 W/m²
Vannbåren distribusjon til varmebatteri	Delta-T: 30.0 °C SPP: 0.5 kW/(l/s)
Kjølebatteri	Nei
Varmegjenvinner	Ja, temperaturvirkningsgrad: 0.90
Vifter	Plassering tilluftsvifte: Etter gjenvinner Plassering avtrekksvifte: Etter gjenvinner
Nattkjøling (frikjøling)	Ja
Nattkjøling når midlere utetemperatur overstiger:	20.0 °C
Nattkjøling når midlere romtemperatur overstiger:	22.0 °C
Nattkjøling når maks. romtemperatur overstiger:	24.0 °C
Nattkjøling avbrytes når tilluftstemperaturen går under:	12.0 °C
Nattkjøling avbrytes når romtemperatur går under:	17.0 °C
Luftmengder ved nattkjøling	Tilluft: 2.0 m³/hm² Avtrekk: 2.0 m³/hm²
SFP-faktor vifter	1.4 kW/m³/s

Inndata teknisk utstyr (internlast)

Beskrivelse	Verdi
Navn:	internlaster bolig (internlaster, teknisk utstyr)
Effekt/Varmetilskudd teknisk utstyr	I driftstiden; Effekt: 3,0 W/m²; Varmetilskudd: 100 % Utenfor driftstiden; Effekt: 0,0 W/m²; Varmetilskudd: 60 % På helg/feriedager; Effekt: 0,0 W/m²; Varmetilskudd: 60 % Antall timer drift pr døgn: 16:00

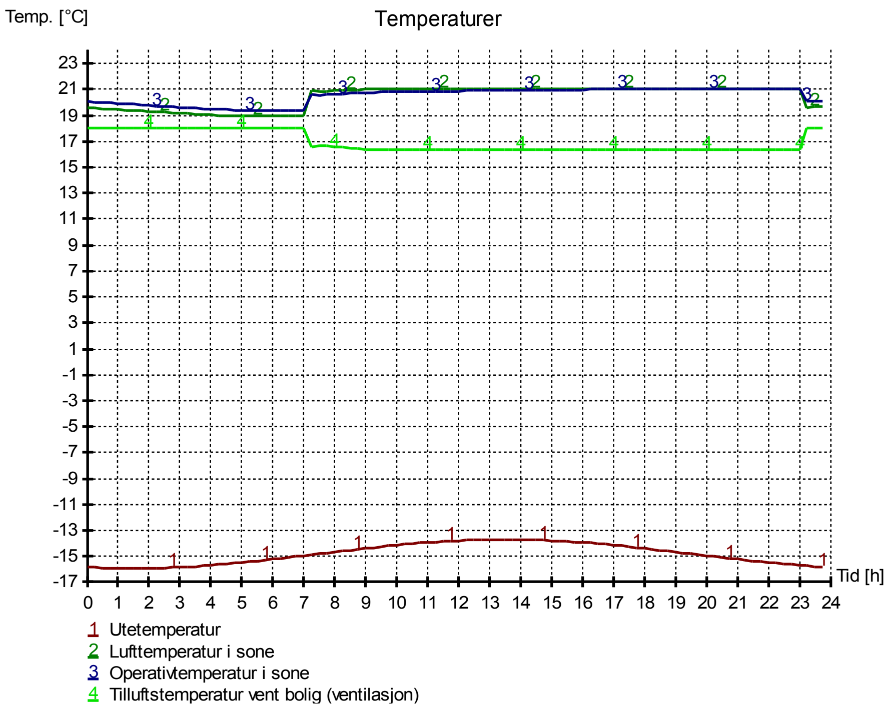
Inndata oppvarming av tappevann

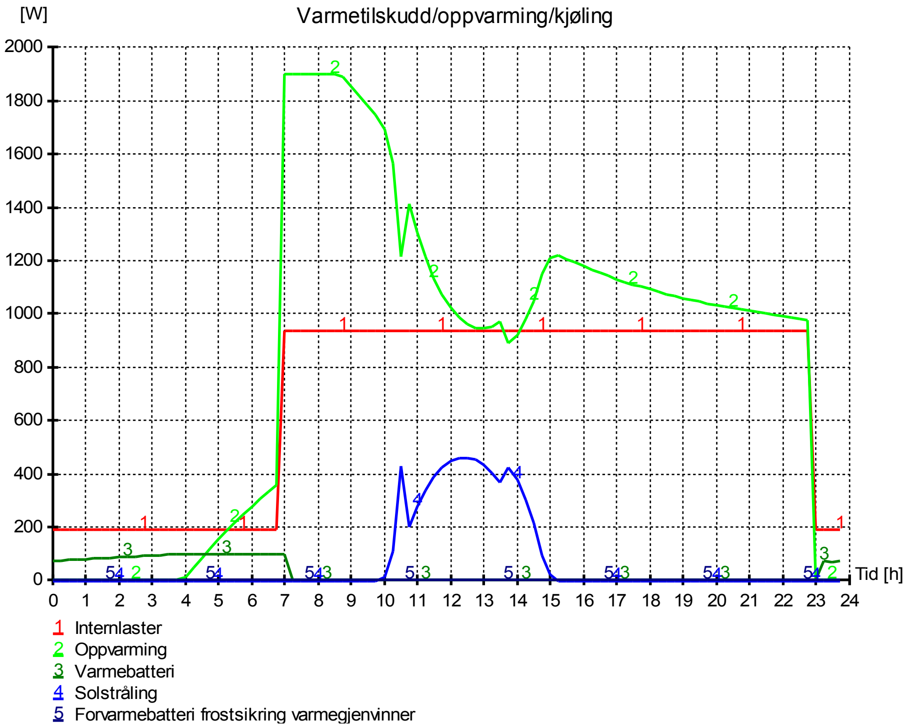
Beskrivelse	Verdi
Navn:	internlaster bolig (internlaster, tappevann)
Tappevann	Driftsdag; Midlere effekt: 5,1 W/m²; Varmetilskudd: 0 %; Vanndamp: 0,0 g/m² Helg/feriedag: Midlere effekt: 0,0 W/m²; Varmetilskudd: 0 %; ; Vanndamp: 0,0 g/m²

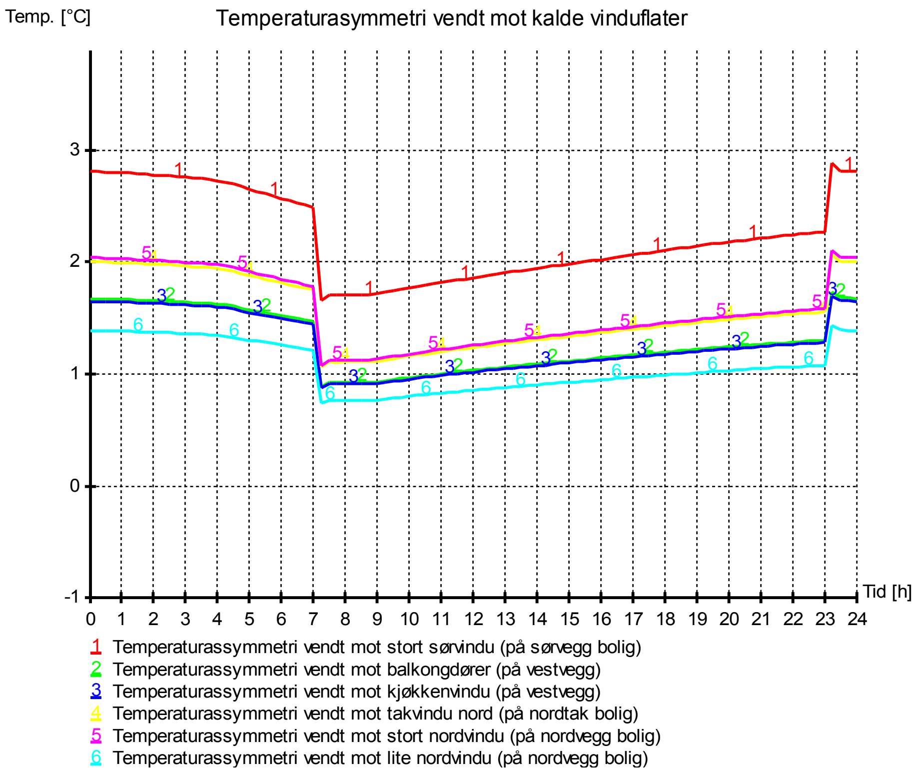
Wintersimulation apartment.

Dimensjonerende verdier		
Beskrivelse	Verdi	Tidspunkt
Maks. samtidig effekt varmebatterier:	100 W / 0,8 W/m²	04:15
Totalt installert effekt varmebatterier	1266 W / 10,0 W/m²	04:15
Maks. samtidig effekt romoppvarming:	1899 W / 15,0 W/m²	07:00
Totalt installert effekt romoppvarming	1899 W / 15,0 W/m²	07:00
Min. romlufttemperatur:	19,0 °C	07:00
Min. operativ temperatur:	19,3 °C	07:00
Maksimal CO2 konsentrasjon (boligdel)	613 PPM	23:15

Sammendrag av nøkkelverdier for boligdel		
Beskrivelse	Verdi	Tidspunkt
Min. innelufttemperatur	19,0 °C	04:15
Min. operativ temperatur	19,3 °C	07:00
Maks. CO2 konsentrasjon	613 PPM	23:15
Maksimal effekt varmebatterier:	100 W / 0,8 W/m²	04:30
Installert effekt varmebatterier	1266 W / 10,0 W/m²	04:30
Maksimal effekt oppvarmingsanlegg:	1899 W / 15,0 W/m²	07:00
Installert effekt romoppvarming	1899 W / 15,0 W/m²	07:00




[W]
Varmetilskudd/oppvarming/kjøling
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Tid [h]
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1 Internlaster
2 Oppvarming
3 Varmebatteri
4 Solstråling
5 Forvarmebatteri frostsikring varmegjenvinner


Temp. [°C]
Temperaturasymmetri vendt mot kalde vinduflater
3
2
1
0
-1
Tid [h]
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
1 Temperaturassymmetri vendt mot stort sørvindu (på sørvegg bolig)
2 Temperaturassymmetri vendt mot balkongdører (på vestvegg)
3 Temperaturassymmetri vendt mot kjøkkenvindu (på vestvegg)
4 Temperaturassymmetri vendt mot takvindu nord (på nordtak bolig)
5 Temperaturassymmetri vendt mot stort nordvindu (på nordvegg bolig)
6 Temperaturassymmetri vendt mot lite nordvindu (på nordvegg bolig)

Inndata teknisk utstyr (internlast)	
Beskrivelse	Verdi
Navn:	internlaster bolig (internlaster, teknisk utstyr)
Effekt/Varmetilskudd teknisk utstyr	I driftstiden; Effekt: 3,0 W/m²; Varmetilskudd: 100 % Utenfor driftstiden; Effekt: 0,0 W/m²; Varmetilskudd: 60 % På helg/feriedager; Effekt: 0,0 W/m²; Varmetilskudd: 60 % Antall timer drift pr døgn: 16:00

Inndata oppvarming av tappevann	
Beskrivelse	Verdi
Navn:	internlaster bolig (internlaster, tappevann)
Tappevann	Driftsdag; Midlere effekt: 5,1 W/m²; Varmetilskudd: 0 %; Vanndamp: 0,0 g/m² Helg/feriedag: Midlere effekt: 0,0 W/m²; Varmetilskudd: 0 %; ; Vanndamp: 0,0 g/m²

Inndata varmetilskudd personer (internlast)	
Beskrivelse	Verdi
Navn:	internlaster bolig (internlaster, varmetilskudd personer)
Varmetilskudd personer	I arbeidstiden: 1,5 W/m² Utenfor arbeidstiden: 0,0 W/m² Ferie/helgedager: 0,0 W/m² Antall arbeidstimer: 24:00