INTEGRATED ENERGY DESIGN
assignment 1

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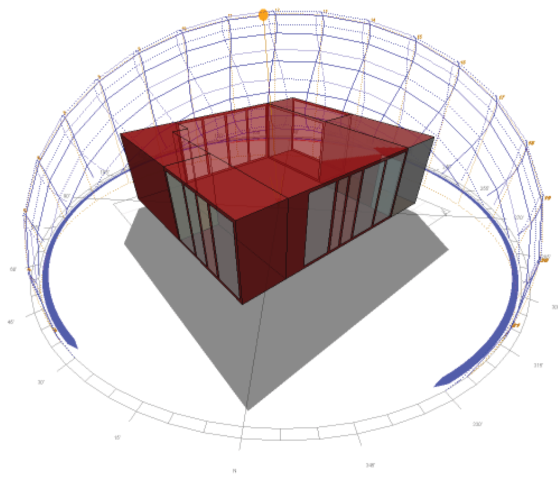


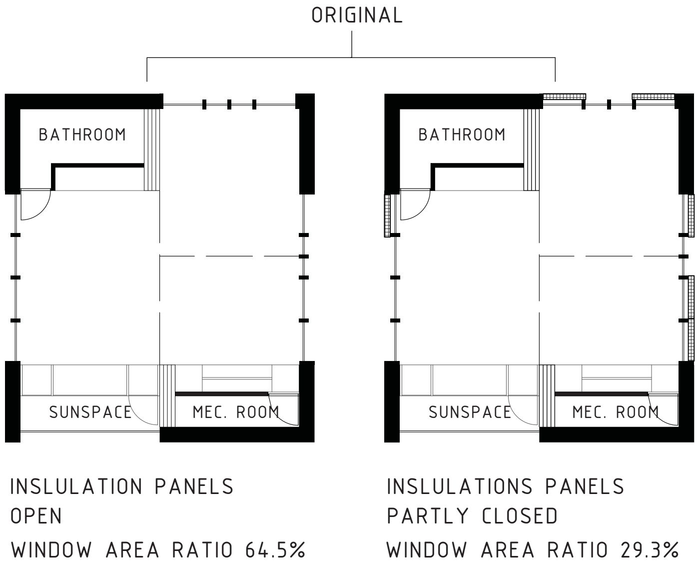
1. INTRODUCTION

This report is a summarize of our groups development of alternativ bulding concept for SDE 2012. We have discussed, analyzed and evaluated the most promising solution.

1.1 CONCEPT DEVELOPMENT

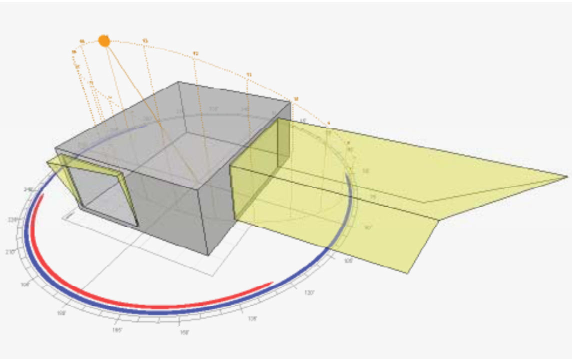
Insulation panels

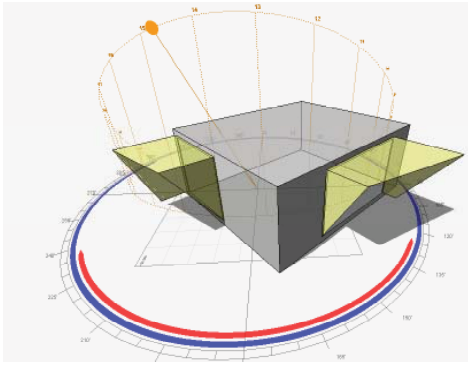
One of the very first thing that caught our attention in the original plan and concept was the amount of glazed area of the house. With all the panels open the glazed area was over 60% of the heated floor area. Due to minimizing heatloss we discussed how to improve the U-value of the walls. With sliding insulated panels we could change the area of the window but we still needed to take the flexibility of the house in to account. It was important to allow many different interior organizations, providing both daylight and views for each possible space organization. It was decided that the window in the living room was important for the external views, so it remained as big as possible, even when the panels are closed as much as we need due to calculations made in Simien according to NS 3031. On the opposite wall, the windows and particions had to be arranged so to allow different interior organization (two bedrooms, one large bedroom, one small room, open-space, etc.)



Orientation

Since the house has glazed areas on every wall, low-angle eastern and western sun cannot be avoided. Howewer, analyses done show that their negative impact can be minimixed by combining house orientation and relatively harmless solution of sushades, harmless in terms of not affecting the views.





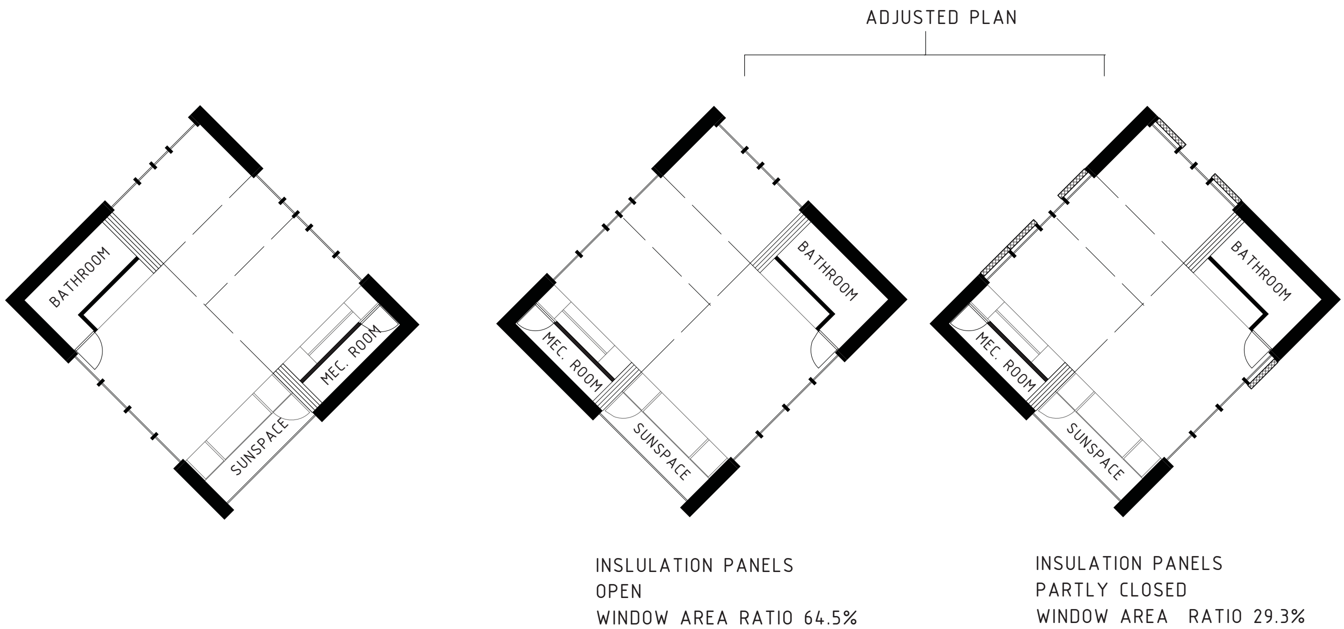
Images above illustrate the needed shading for different orientations of the house. As expected, low angle sun on east facade requires insensilbe sun protection. By rotating the house, so that the longer facade faces south-east results in reasonably sized sun protection over each glazing area.

Sun protection

In order to protect from low-angle sun coming from east and west, vertical fins have proven to be the best option. However, they usually completly block the view through the glazing, which is in contradiction with its main function. By orienting the house so that none of the facades directly faces east or west, it was possible to design a sun protective system that would not interfere with the views.

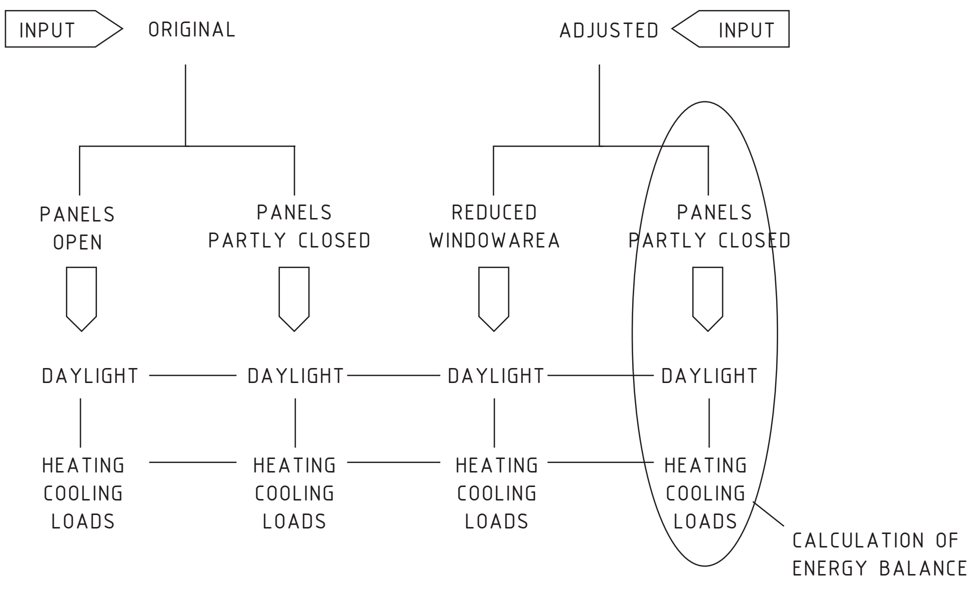
Internal organization
After previous interventions the living room is now facing south-west, see image below to the left. This orientation is not optimum as the only sun it gets is the low angle western sun. Besides being a possible source of glare, the sunshine enters the room in the afternoon hours, when temperatures are already high.

As a simple solution, it was decided to rearrange the internal space organization by mirroring the plan.
This way the living room is facing south-east and therefore get plenty of sunshine. The morning sun coming from east can easily be protected from.



1.1 ALTERNATIVE CONCEPTS

We now have four different versions of building concepts that we want to analyse and compare. The first thing is to make sure that the daylight factor is good enough for our adjusted plan with panel partly closed. And then compare the heating and cooling loads to evalute if the adjustments in plan have made any impact on the energy demand.



2. ANALYSIS OF ALTERNATIV BUILDING CONCEPTS

2.1 INPUT

The input in ECOTECT :

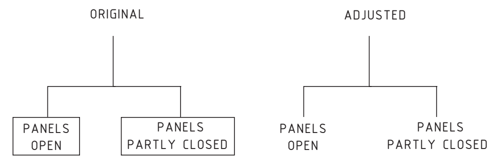
U-VALUES

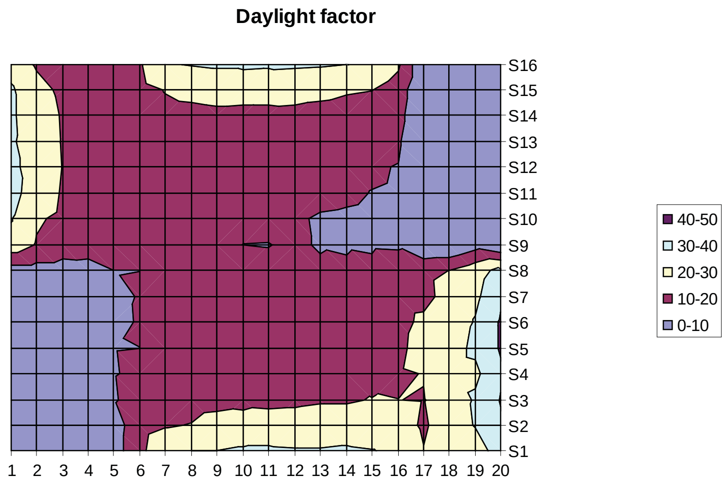
Roof	0,13 W/m2K
Windows	0,33 W/m2K
Walls	0,17 W/m2K
Floor	0,15 W/m2K
Windows with panel	0,17 W/m2K

OCCUPANCY AND OPERATION
2 people
Sedentary activity 70W
Air change rate Average 1.0 ach

2.2 DAYLIGHT

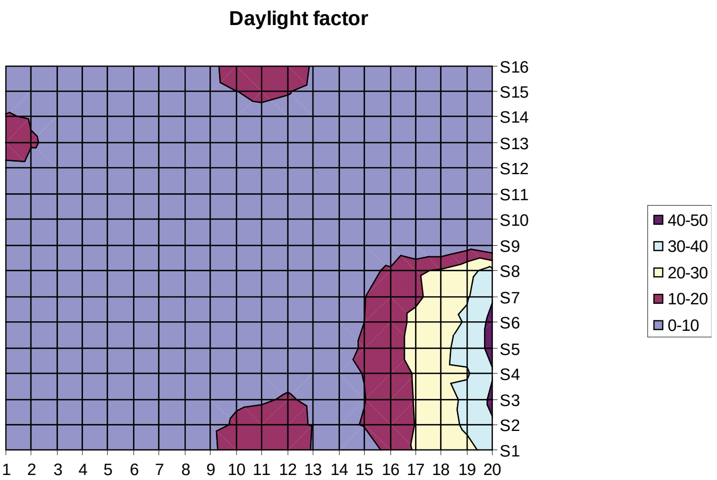
We now have four different versions of building concepts that we want to analyse and compare. The first thing is to make sure that the daylight factor is good enough for our adjusted plan with panel partly closed. And then compare the heating and cooling loads to evalute if the adjustments in plan have made any impact on the energy demand.



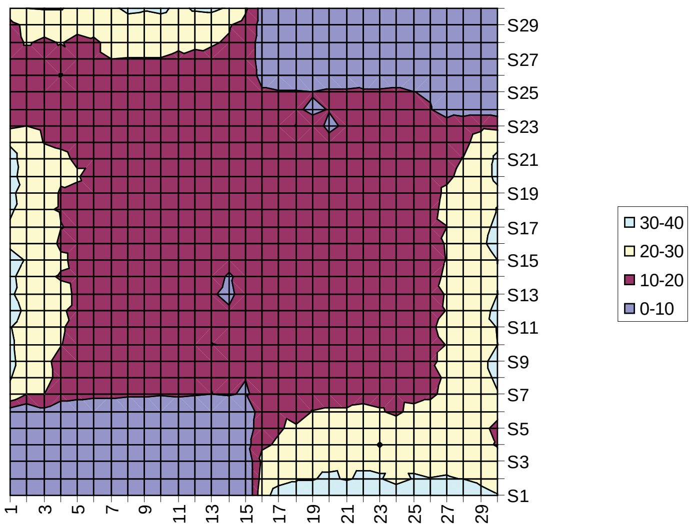


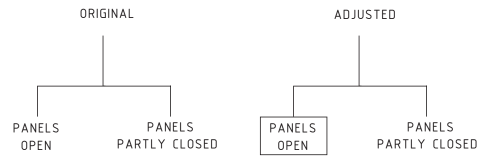
Case 1
The original design was based on the concept of flexibility and open space and aimed to provide a considerable amount of daylight into the house and allow a wide view of the landscape. This was made possible thanks to the large area of glazing (64% of the floor area) and the distribution of the windows all over the house.

The large surface of windows can be an asset regarding daylight factor but can quickly become a liability in the extremes seasons even with a good U-value.



Case 2
In order to reduce the heat loss and gain due the glazing area, our second concept includes sliding insulated panels. In this way the total surface of windows in our house represented 29% of the floor area. According to the calculations made by the engineers in Siemen, this surface is enough to respect the passivehus standards, due to our very low U-values (on both walls and windows).
The daylight factor provided when the panels are closed is quite low and doesn't keep the concept of a "solar house". In order to use the sun light in a better way, we have though that a better orientation and layout of the plan will help us improving its use.



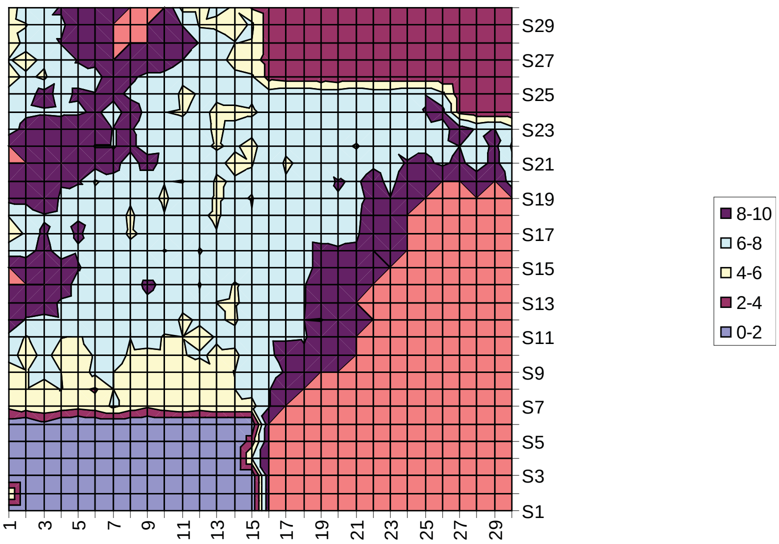


Case 3

64,5% window area but with the plan mirrored and rotated 45 degrees to improve orientation and use/protection of sun. We start the calculations **without any partitions.**

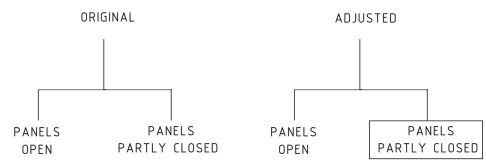
We get a quite uniform and high daylight factor throughout the open plan of the house.

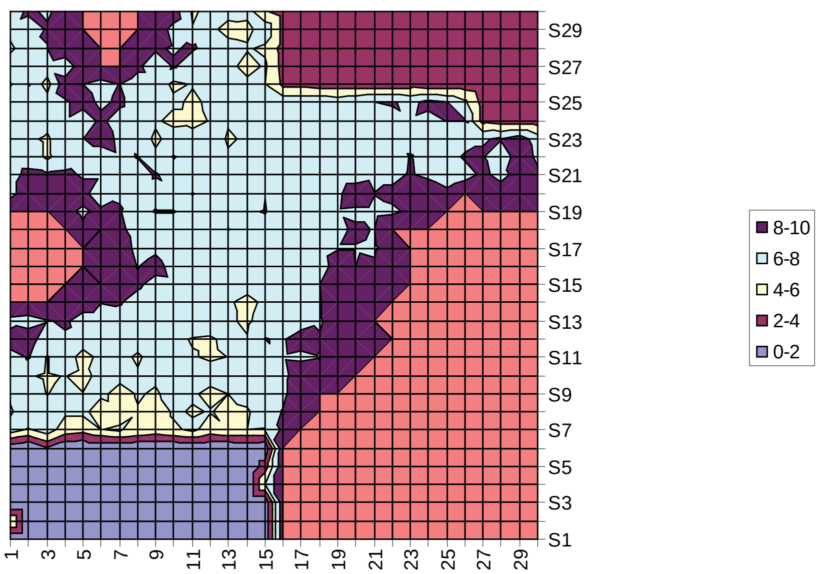
Conventional reduction of windowarea



Case 4

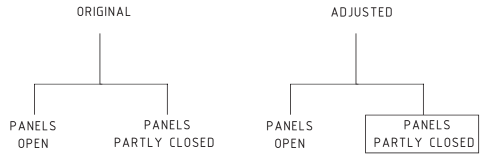
Conventional reduction of window area by transforming the large windows in the bedroom zone into smaller square windows, to be able to comply with the restrictions on NS3031. **Without any partitions.**
We get a quite uniform and high daylight factor throughout the open plan of the house.

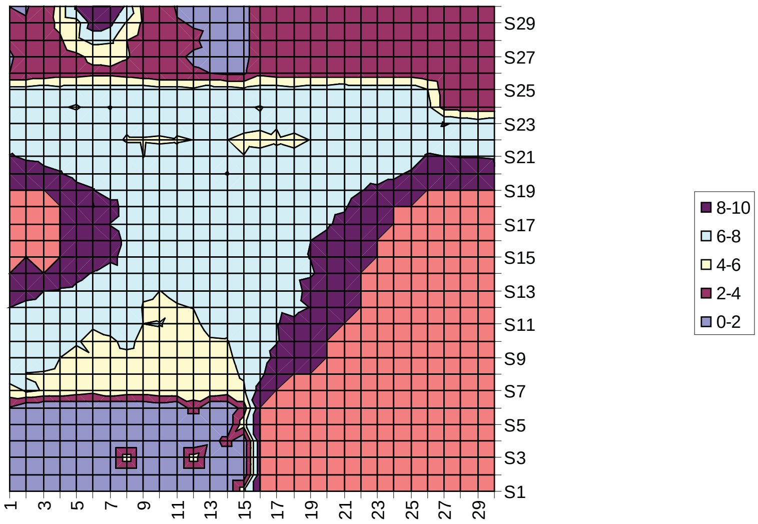




Case 5

Same reduction of window area as above but keeping the architectural concept for the window shape (from floor to ceiling). We just put insulating panels to partially cover our windows. **Without any partitions.**
As we can see, this way of reducing the window area gives us a better distribution of the daylight factor in our space. There is therefore more advantageous to keep the vertical disposition of the windows, instead of changing them into more conventional square ones.



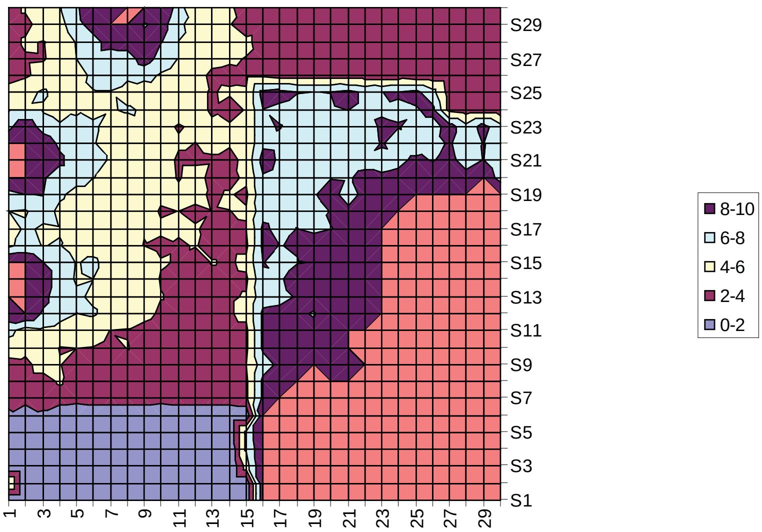


Case 6

After reducing the window area, we should check that the daylight conditions in our house are sufficient with the partitions (so that we won't need to turn on any artificial lights during the day), and that means DaylightFactor>2% according to Norwegian standards.

We start with putting in place the smallest of the internal partitions: **Bachelor disposition**.

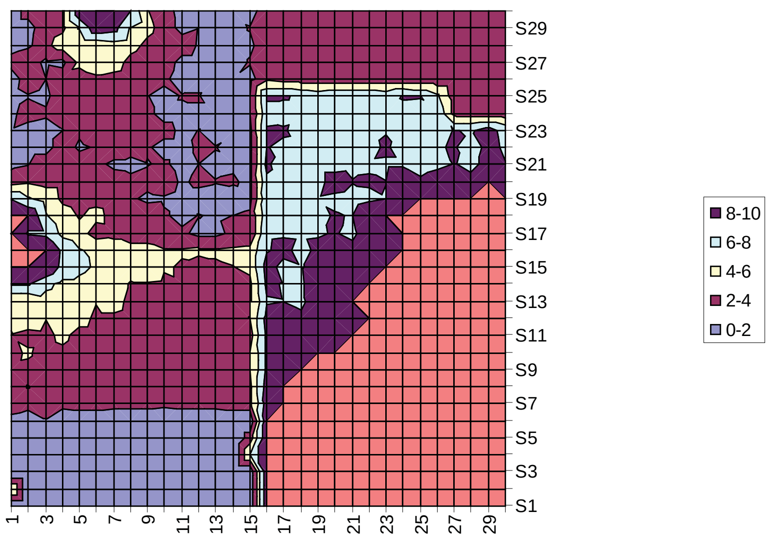
We can see that even though the small bedroom just has a window to the North-East, the daylight factor is still sufficient in most of the area (since it is a bedroom, we don not really need so much light by the bed).



Case 7:

We should also check the effect of closing the long partition to divide the space into day and night areas: **Couple disposition.**

With this disposition of the partitions we get a quite good distribution for the natural light, due to the fact that we still have quite an open plan, and the windows are also quite spread.

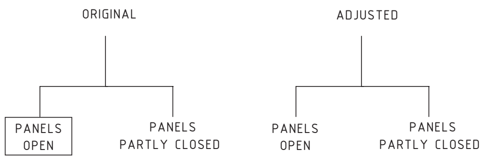


Case 8

The most restrictive disposition of the partitions is when we close all of them to create a more conventional plan distribution that includes two bedrooms: Family disposition.

We can see that though the daylight factor has got very reduced in the bedrooms of the house and it is lowest in the smallest bedroom, it is still sufficient in most of the area.

2.2 HEATING AND COOLING LOADS



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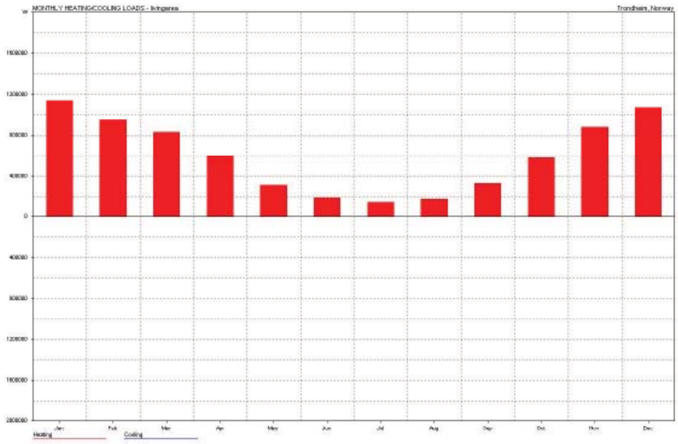
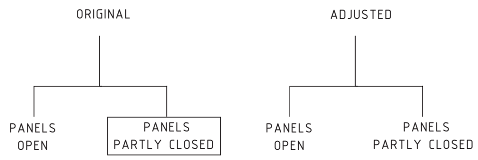


MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

Max Heating: 4802 W at 15:00 on 15th January
Max Cooling: 0.0 C - No Cooling.

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	113648	0	1136487
Feb	952598	0	952598
Mar	833880	0	833880
Apr	603188	0	603188
May	310848	0	310848
Jun	187995	0	187995
Jul	144938	0	144938
Aug	172166	0	172166
Sep	331022	0	331022
Oct	578676	0	578676
Nov	880103	0	880103
Dec	106790	0	1067900
TOTAL	7199,800		7199,800
PER M²	163930	0	163930
Floor Area:	43.920 m2		



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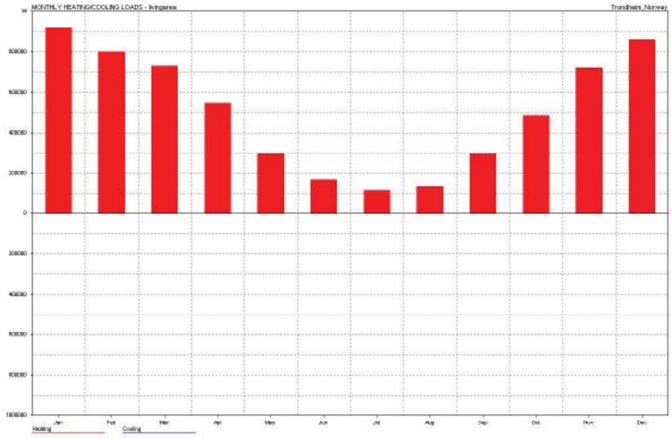


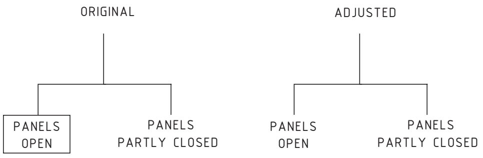
MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

Max Heating: 4010 W at 15:00 on 15th January
Max Cooling: 0.0 C - No Cooling.

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	921156	0	921156
Feb	799637	0	799637
Mar	728554	0	728554
Apr	544620	0	544620
May	293875	0	293875
Jun	166532	0	166532
Jul	114236	0	114236
Aug	135711	0	135711
Sep	293873	0	293873
Oct	485798	0	485798
Nov	719649	0	719649
Dec	861338	0	861338
TOTAL	6064,980		6064,980
PER M²	138092	0	138092
Floor Area:	43.920 m2		

In Trondheim, the use of the panels makes a great difference in the heating demand. The heat losses trough the windows have been avoided thanks to the panels. The new heating demand is now 84% of the former one.



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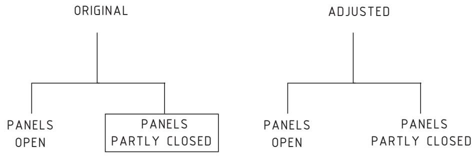

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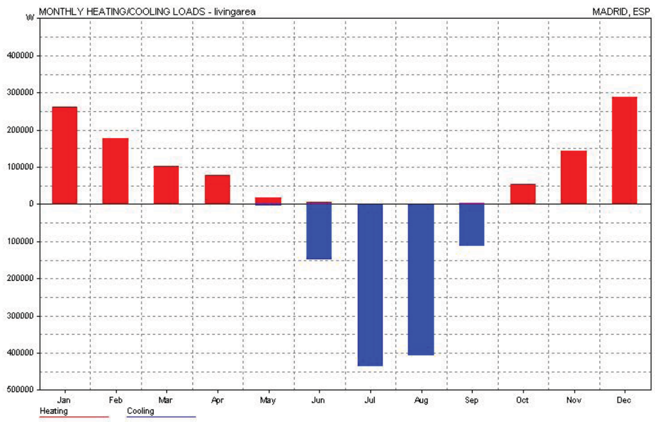
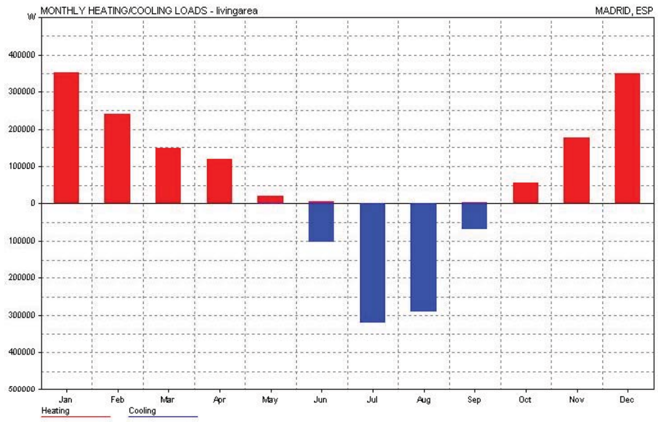




MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

Max Heating: 1680 W at 23:00 on 4th February
Max Cooling: 2726 W at 15:00 on 20th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)	
Jan	263176	0	263176	
Feb	177520	0	177520	
Mar	102443	0	102443	
Apr	78840	0	78840	
May	17877	3240	21117	
Jun	6259	147532	153791	
Jul	0	43552	435526	
Aug	242	408107	408349	
Sep	3345	111162	114508	
Oct	53780	0	53780	
Nov	143476	0	143476	
Dec	289790	0	289790	
TOTAL	1136,747	1105,568		2242,314
PER M²	25882	25172	51055	
Floor Area:	43.920 m2			

MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

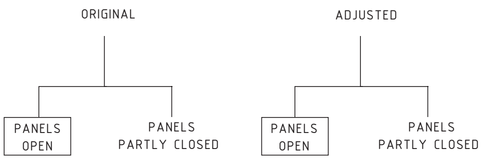
Max Heating: 1675 W at 23:00 on 4th February
Max Cooling: 1929 W at 15:00 on 20th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)	
Jan	351042	0	351042	
Feb	239999	0	239999	
Mar	147950	0	147950	
Apr	120496	0	120496	
May	20173	795	20969	
Jun	6168	103835	110003	
Jul	0	31928	319280	
Aug	343	291768	292111	
Sep	4253	69934	74187	
Oct	56033	0	56033	
Nov	178451	0	178451	
Dec	349719	0	349719	
TOTAL	1474,626	785,613		2260,240
PER M²	33575	17887	51463	
Floor Area:	43.920 m2			

In Madrid in summer we'll need only 77% of our previous energy demand when using the insulated panels. However in winter, it's better to keep the panels closed as the heat provided by the sun is enough to fight the heat losses through the glazing area (68% of heating demand compared to a "closed house")

With the system of sliding panels we have seen that the dynamic approach was more suitable to a passive house. Indeed, as seen in the results it's important to have the windows shaded in Madrid in summer but we take more advantage of large south windows in winter to heat the house. Thus, a static approach (for example reducing the glazing area) wouldn't make sense in Madrid.

COMPARISON



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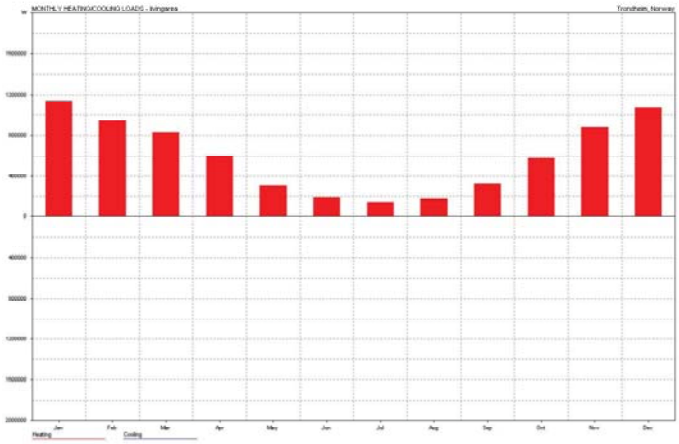

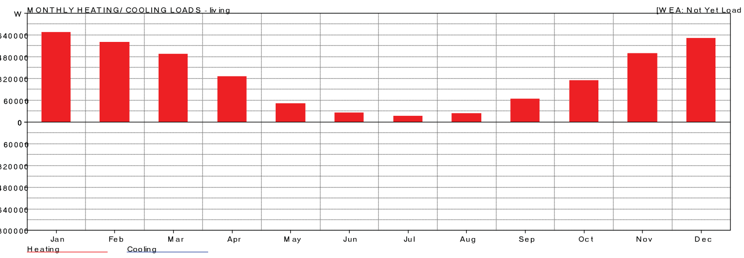

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Jul	144938	0	144938
Aug	172166	0	172166
Sep	331022	0	331022
Oct	578676	0	578676
Nov	880103	0	880103
Dec	106790	0	1067900
TOTAL	**7199,800**		**7199,800**
PER M²	163930	0	163930

Floor Area: 43.920 m2

MONTHLY HEATING/COOLING LOADS – case 3 - Trondheim

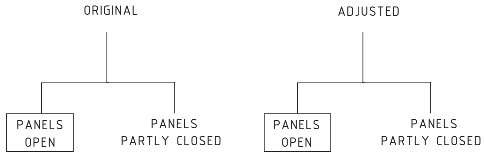
All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 4747 W at 19:00 on 15th January
Max Cooling: 1631 W at 11:00 on 19th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	659360	0	659360
Feb	583759	0	583759
Mar	495386	0	495386
Apr	330025	0	330025
May	132193	0	132193
Jun	63240	0	63240
Jul	40150	0	40150
Aug	60254	3257	63510
Sep	166447	0	166447
Oct	300895	0	300895
Nov	500430	0	500430
Dec	613006	0	613006
TOTAL	3945145	3257	3948402
PER M²	74046	61	74107

Floor Area: 53.280 m2

COMPARISON



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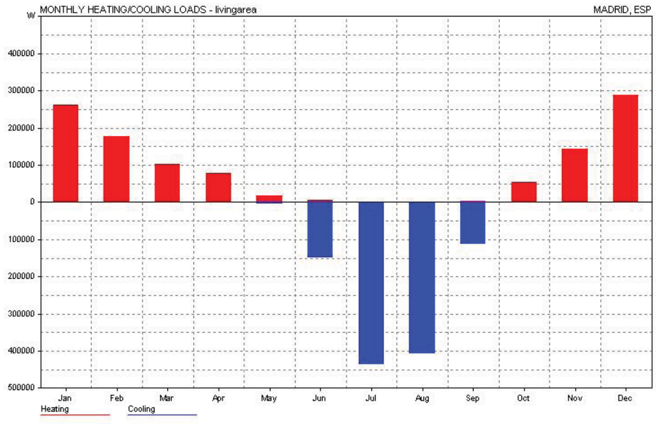

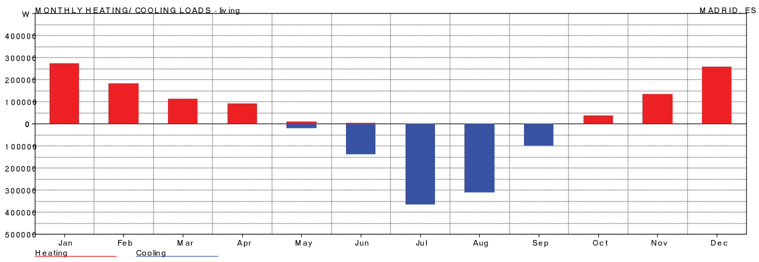

MONTHLY HEATING/COOLING LOADS

Zone: livingarea
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Feb	177520	0	177520	
Mar	102443	0	102443	
Apr	78840	0	78840	
May	17877	3240	21117	
Jun	6259	147532	153791	
Jul	0	43552	435526	
Aug	242	408107	408349	
Sep	3345	111162	114508	
Oct	53780	0	53780	
Nov	143476	0	143476	
Dec	289790	0	289790	
TOTAL	1136,747	1105,568		2242,314
PER M²	25882	25172	51055	

Floor Area: 43.920 m2

MONTHLY HEATING/COOLING LOADS – case 3 - Madrid

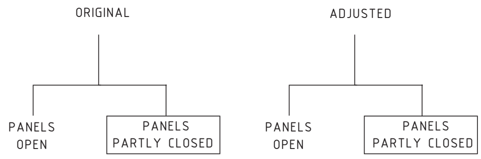
All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 2094 W at 23:00 on 22nd January
Max Cooling: 3187 W at 14:00 on 5th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	273397	0	273397
Feb	182605	0	182605
Mar	113510	0	113510
Apr	91384	0	91384
May	9309	19950	29259
Jun	4071	136741	140812
Jul	0	363855	363855
Aug	52	311616	311668
Sep	667	98694	99361
Oct	38513	0	38513
Nov	135165	0	135165
Dec	258792	0	258792
TOTAL	1107465	930857	2038322
PER M²	20786	17471	38257

Floor Area: 53.280 m2

COMPARISON



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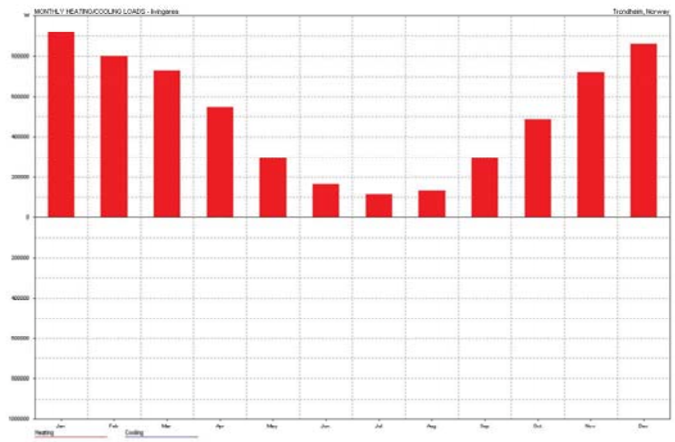
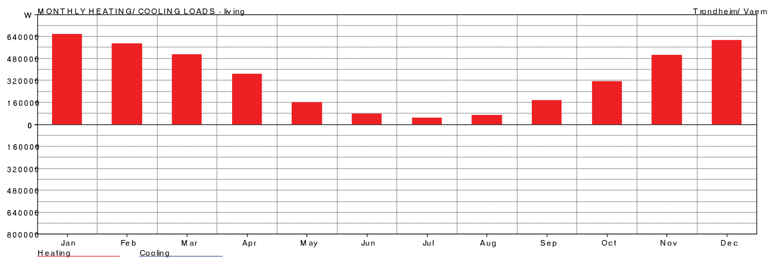




MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

Max Heating: 4010 W at 15:00 on 15th January
Max Cooling: 0.0 C - No Cooling.

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	921156	0	921156
Feb	799637	0	799637
Mar	728554	0	728554
Apr	544620	0	544620
May	293875	0	293875
Jun	166532	0	166532
Jul	114236	0	114236
Aug	135711	0	135711
Sep	293873	0	293873
Oct	485798	0	485798
Nov	719649	0	719649
Dec	861338	0	861338
TOTAL	6064,980		6064,980
PER M²	138092	0	138092

Floor Area: 43.920 m2

MONTHLY HEATING/COOLING LOADS – case 5 - Trondheim

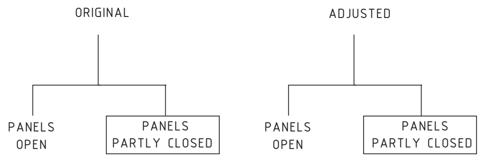
All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 4911 W at 16:00 on 15th January
Max Cooling: 1239 W at 12:00 on 19th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	656286	0	656286
Feb	584156	0	584156
Mar	508026	0	508026
Apr	363316	0	363316
May	158262	0	158262
Jun	76497	0	76497
Jul	46496	0	46496
Aug	63837	1239	65076
Sep	175574	0	175574
Oct	309326	0	309326
Nov	501336	0	501336
Dec	609114	0	609114
TOTAL	4052226	1239	4053465
PER M²	76055	23	76079

Floor Area: 53.280 m2

COMPARISON



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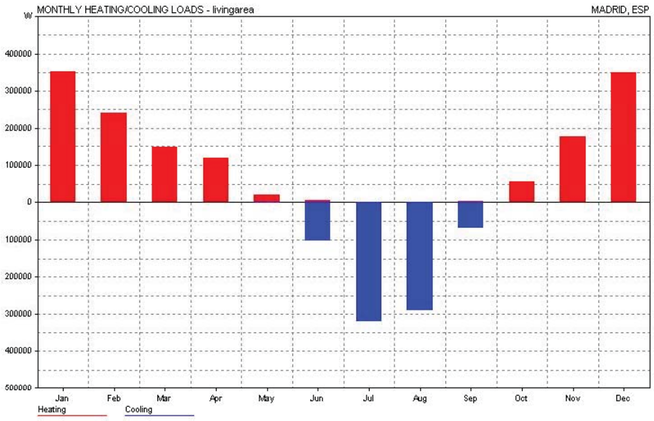
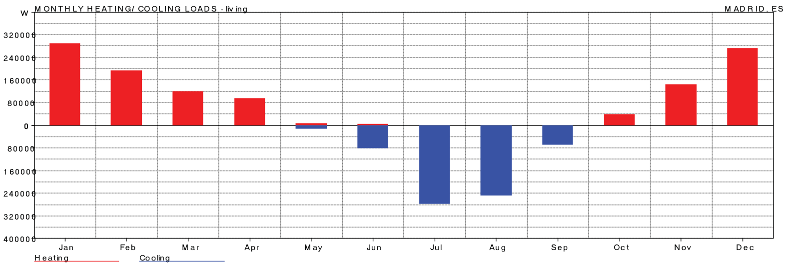




MONTHLY HEATING/COOLING LOADS

Zone: livingarea
Operation: Weekdays 09-23, Weekends 09-24.
Thermostat Settings: 22.0 - 26.0 C

Max Heating: 1675 W at 23:00 on 4th February
Max Cooling: 1929 W at 15:00 on 20th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	351042	0	351042
Feb	239999	0	239999
Mar	147950	0	147950
Apr	120496	0	120496
May	20173	795	20969
Jun	6168	103835	110003
Jul	0	31928	319280
Aug	343	291768	292111
Sep	4253	69934	74187
Oct	56033	0	56033
Nov	178451	0	178451
Dec	349719	0	349719
TOTAL	1474,626	785,613	2260,240
PER M²	33575	17887	51463

Floor Area: 43.920 m2

MONTHLY HEATING/COOLING LOADS – case 5 - Madrid

All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 2019 W at 23:00 on 22nd January
Max Cooling: 2640 W at 15:00 on 5th August

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	287933	0	287933
Feb	191836	0	191836
Mar	118841	0	118841
Apr	95604	0	95604
May	6516	12415	18931
Jun	4000	82915	86915
Jul	0	278017	278017
Aug	0	248916	248916
Sep	0	68842	68842
Oct	38288	0	38288
Nov	143689	0	143689
Dec	271593	0	271593
TOTAL	1158300	691105	1849405
PER M²	21740	12971	34711

Floor Area: 53.280 m2

2.4 CONLUSION

To be able to compare the full window area and the reduced one (with the insulating panels), and the original and the improved plan disposition (mirrored and rotated), we performed a thermal analysis in all of them, both for Trondheim and for Madrid.

In order to check how much we could improve the original design, we will compare them two on two for the same conditions.

- Trondheim - open:
With the original plan, we get a total thermal demand of 7.199,800 kWh with no need for cooling, while with the new plan we manage to reduce that to only 3.948,402 kWh (with 3,257 kWh of cooling in August).

- Madrid – open:
The original plan has a total thermal demand of 2.242,314 kWh (1.136,747 kWh for heating and 1.105,568 kWh for cooling), while the new plan gives us a small reduction in it with 2.038,322 kWh (1.107,465 kWh for heating and 930,857 kWh for cooling).

- Trondheim – closed:
With the original plan we need a total of 6.064,980 kWh of heating and no cooling, while with the new plan we go down to only 4.053,465 kWh (with 1,239 kWh of cooling in August).

- Madrid – closed:
The original plan has a total thermal demand of 2.260,240 kWh (1.474,626 kWh of heating and 930,857 kWh of cooling), and the new plan manages to slightly lower that to 1.849,405 kWh (1.158,300 kWh for heating and 691,105 kWh for cooling).

After comparing the two solutions both in Trondheim and in Madrid, we can conclude that we have managed to improve the thermal demands of the building (in a higher level in Trondheim than in Madrid) by mirroring the plan and rotating it 45 degrees, independently of any other measures. Then again, by reducing the window area, we get even lower thermal energy demands, without compromising the lighting levels in the interior.

So we can conclude that the optimal solution of the ones analysed is with the new plan and flexible disposition of the window area (being able to close it with insulated panels or some other element with similar effect), so that we can adapt to different situations, seasons and locations. This is because the optimal results for Trondheim were with the new plan and full window area, while for Madrid it was better with the new plan and reduced window area.

3. CALCULATIONS IN SIMIEN

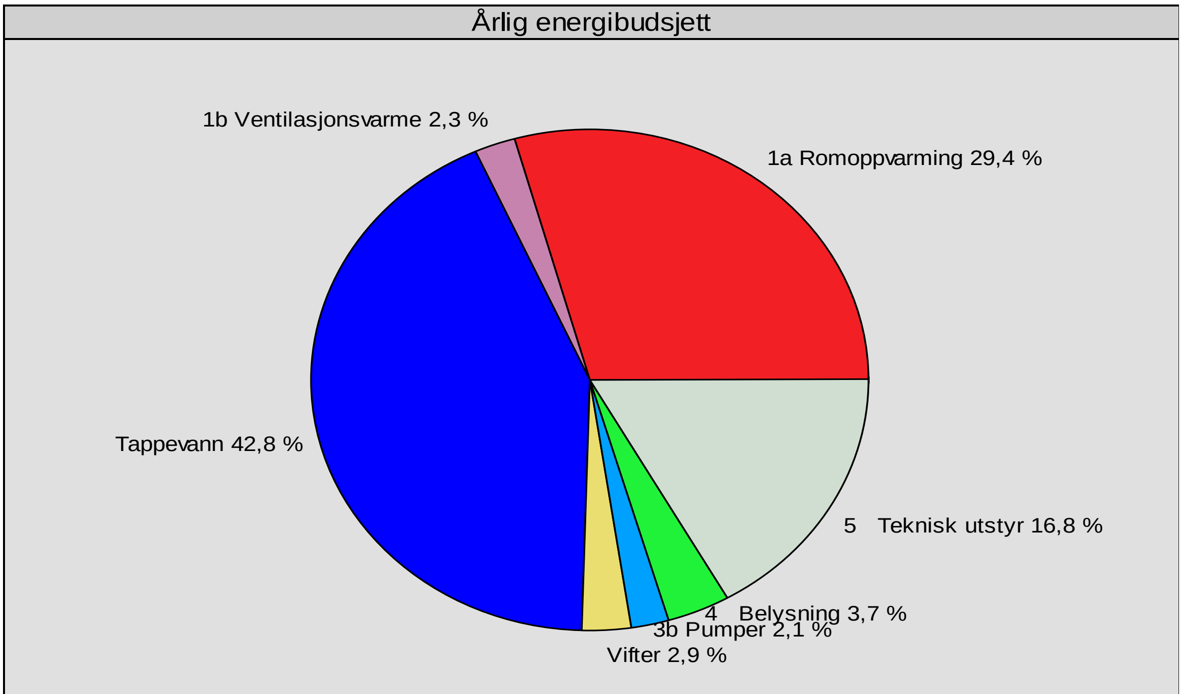
To calculate the energy budget for ZE+ hytte, we used a program called SIMIEN. All the values used in the program can be found in appendix 1. The results for the heat loss calculations can be found in table 1.

The total heat loss coefficient is 0.6 W/m^{2}K, which is the same as the passive house demand. Because the specific heating number is higher than 24.0 kWh/m^2[1], we didn't meet the passive house demand, but this is difficult with a house with a heated floor area of only 59 m^2.

Varmetapstall yttervegger	0,08 W/m²K
Varmetapstall tak	0,17 W/m²K
Varmetapstall gulv på grunn/mot det fri	0,10 W/m²K
Varmetapstall glass/vinduer/dører	0,13 W/m²K
Varmetapstall kuldebroer	0,03 W/m²K
Varmetapstall infiltrasjon	0,03 W/m²K
Varmetapstall ventilasjon	0,06 W/m²K
Totalt varmetapstall	0,60 W/m²K

Table 1. Heat loss numbers

ANNUAL ENERGY BUDGET



1a Romoppvarming	1811 kWh
1b Ventilasjonsvarme (varmebatterier)	142 kWh
2 Varmtvann (tappevann)	2637 kWh
3a Vifter	178 kWh
3b Pumper	132 kWh
4 Belysning	226 kWh
5 Teknisk utstyr	1034 kWh
6a Romkjøling	0 kWh
6b Ventilasjonskjøling (kjølebatterier)	0 kWh
Totalt netto energibehov, sum 1-6	6159 kWh

Table 2. Energy budget

After the calculations with SIMIEN, we get an annual energy demand of 6159 kWh. The biggest part of the demand is heating of the hot water (42.8 %). This part has the most potential to be reduced, with pre heating of the water with a solar collector. It is also possible to reduce the heating of the ventilation air, by using the heat from the sun space in a rotating heat exchanger.

Lighting

The cabin is small and the use of natural sun light can minimize the artificial light during the day. Electric light is only needed in the evening, and with the use of high efficient LED, the power use for lighting can be small. You can also include a smart system for controlling and regulation the amount of light needed. LED uses DC current, so the power from the storage battery doesn't need to be converted to AC. LED is also easy to integrate in the controlling system since it semiconductors that produces the light. Also on LCA (Life Cycle Analysis) perspective the LED lamps are better than normal types of lamps [2].

DELIVERED ENERGY TO THE BUILDING

Levert energi til bygningen (beregnet)		
Energivare	Levert energi	Spesifikk levert energi
1a Direkte el.	0 kWh	0,0 kWh/m²
1b El. Varmepumpe	544 kWh	9,2 kWh/m²
1c El. solenergi	3821 kWh	64,8 kWh/m²
2 Olje	0 kWh	0,0 kWh/m²
3 Gass	0 kWh	0,0 kWh/m²
4 Fjernvarme	0 kWh	0,0 kWh/m²
5 Biobrensel	0 kWh	0,0 kWh/m²
6. Annen ()	0 kWh	0,0 kWh/m²
Totalt levert energi, sum 1-6	4364 kWh	74,0 kWh/m²

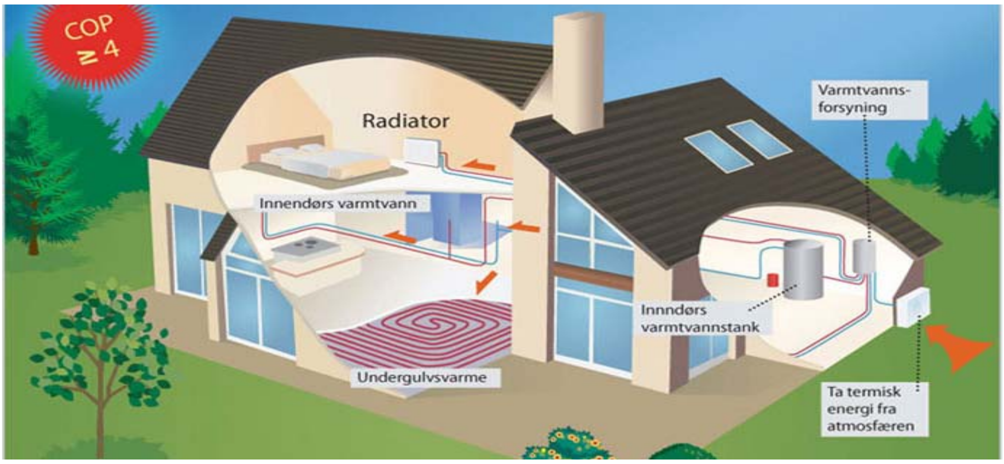
Table 3. Delivered energy to the building

Electric car

It takes 8 hours to charge the electric car from empty to full, and this takes about 30 kWh[3]. With a full tank, you can drive up to 160 km. If you charge your car 1.5 times a week for one year, the total energy consumption is 2340 kWh. Today it is possible to charge your electric car for free many places around in the city; this will help reduce your charging at home.

Heat pump

The energy budget shows that we need 6159 kWh to meet the annual energy demand. With the air-water heat pump with COP = 4.3[4], we can reduce this number to 4364 kWh. The heat pump is used on central heating in the floor, and not in radiators on the wall. 20 % of the energy used to heat the water in the boiler comes from the heat pump, the rest comes from electricity



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Total delivered energy to the building
If we include the charging of the electric car the total annual energy demand is 6704 kWh.

SOLAR CELLS

To evaluate if the cabin could only be supported by only solar power, an average solar irradiation evaluation [5] on a monthly time basis in Oslo had to be done (Appendix 2). This is to evaluate the available power of the system. Usually the pv panels are used to support low power demanding devices like lighting, television, and other electric devices. An example on how to meet a small power demand is having one big hot plate operation on full power 1500W in January. The pv panels with an efficiency of 0.2 will produce 11,5W/m^2 . This means that we need the surface area of pv-panels to be 1500W/11,5Wper m^2 = 130 m^2, to generate the power to support only the hot plate. This supports the idea of the cabin being connect to the grid, to be able to reach the power peaks in season where the sun irradiation is low, and also to achieve the plus house status.
Another approach is to use other energy sources on the high power demanding activities, like using gas for cooking. There are lots of scenarios that needed to be analyzed, and storing and "selling" on the grid when there is a surplus of energy.

Simen consumption vs pv production
Comparing the produced power from pv panels versus the only the heating demand simulated in SIMIEN on an hourly basis in Januray, we can see that in one of the worst months the production from the pv panels(40m^2) is not far from reaching the power the heating of the cabin will need.

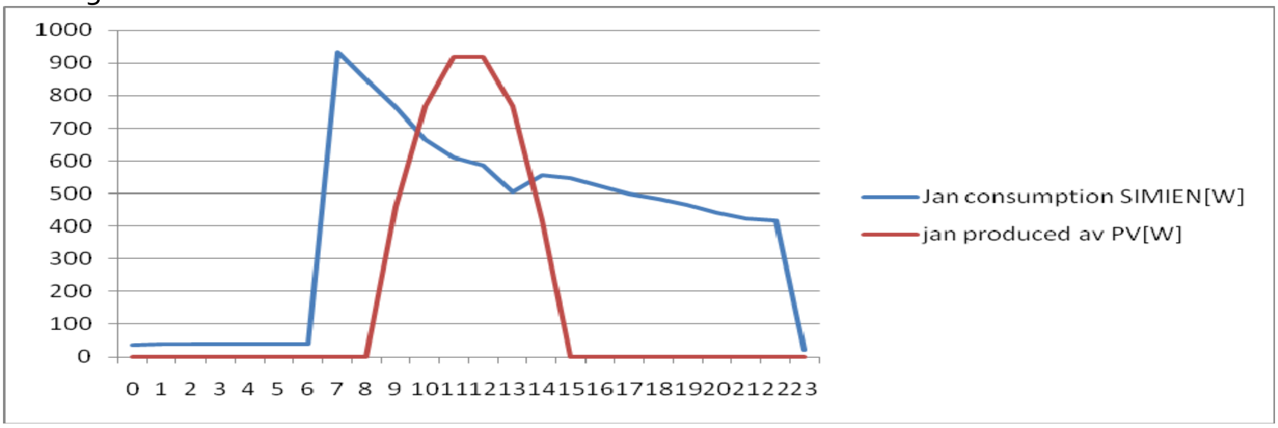

Figure 1. Power consumption

On the contrary the energy demand on a kWh basis, the house will produce more than it uses according to the calculation we have done. So the task for future work is to develop smart ways to store and sell, and to be able to reach power peaks in worst case scenarios in a good way.

	jan	feb	mar	apr	mai	jun	jul	aug	sep	okt	nov	des
total [Wh/m2*day]	106	266	483	764	976	1051	991	793	585	318	151	91
total [kWh/m2*month]	3	7	15	23	30	32	31	25	18	10	5	3
total month with a area of 40m2 PV [kWh]	132	298	599	917	1210	1262	1228	983	702	394	181	112

Total net productiom[kWh]	8019
Total net energy needed[kWh]	6704
Surplus [kWh]	1315

Table 4. Power production

From the table above the surplus of energy with a $40m^2$ pv panels on the roof will give a yearly surplus of 1315,5 kWh. The house is a plus house since its yearly produce more than it uses.

Future work is finding smart ways to mount the pv panels on the roof, to avoid snow covering the panels.

REFERENCES

[1] NS 3700:2010, Kriterier for passivhus og lavenergihus, Boligbygninger

[2] en.Wikepedia.org/LED

[3] http://think.no/nor/THINK-City/Lading/Batterier

[4] http://www.general.no/varmepumpe-vann

[5] http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#

APPENDIX

Appendix 1. Data input in SIMIEN

City
The calculation was made for Oslo, Norway.

Floor
Total floor area 75 m^2
Circumference floor 30.8 m
The simulation is done with a u-value of 0.09.
Extra thermal isolation along the edge of the floor, 0.6 m vertical edge isolation with 50 mm XPS (thermal conductivity 0.034).
Assume that the building stands on dayey soil.
Thermal conductivity in the floors indoor is simulated as heavy floor whit thermal conductivity 63 Wh/m^2K.

Ceiling
The simulation is done with a u-value of 0.13.
The ceiling is simulated as medium heavy ceiling. This gives a thermal conductivity of 13 Wh/m^2K.
We have not included the heating from the sun that shine on the roof.

Wall
Area wall north-east and south-west 9*2.45 = 22.05 m^2
Area wall south-east and north-west 8*2.45 =19.6 m^2

The wall is simulated with a u-value of 0.08.
The south-east and south-west wall are exposed for sun with an outside absorption coefficient of 0.8.
The inside wall is simulated as it was compact wood with 40 mm width or more.

Windows
Super isolated window frame of wood. The u-value is assumed to be 0.65.
The u-value of the window glass is 0.3.
The areas of the windows are
North-west 0.4m*2,35m 2 units
North-east 0.5m*2,35m
South-west 3m*2,35m
South-east 3m*2,35m

Internal load
The period the electric light is on (hour of the day):

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Des
14-24	15-24	16-24	17-24	18-24	19-24	20-24	20-24	19-24	17-24	15-24	14-24

We assume that the light is so effective that it only consume 1.5 W/m^2.

Heating
Maximal effect 50 W/m^2
Flow temperature 38^{o}C
Return temperature 32^{o}C
SPP 0,5kW/^{l}/s

Set point temperature in the daytime is 21^{o}C
Set point temperature in the night is 19^{o}C

The summer is set from May to September
In this time the set point temperature in the daytime is set as 20^{o}C and the set point temperature in the night is set as 16^{o}C.

Ventilation
The air flow is regulated in order to keep the CO_2-level below 800 ppm and the air temperature below 25^{o}C.

In daytime the maximum air flow rate are set to 1.4 m^3/(hm^2) and the minimum air flow rate are set to 1.2 m^3/(hm^2)
In the night the air flow rate are set to 1.2 m^3/(hm^2)

SFP-factor is 1.

The normal supply air temperature is set to 19^{o}C.
In the summer the temperature are set to 17^{o}C.
Summer is set from May to August.
Uptime is set to 6.00 to 24.00.

Heating coil has a maximum capacity of 10 W/m^2
The waterborne heating battery has a delta-T waterside at 30 K and specific pump effect at 0.5 kW/(^{l}/s).

The rotating heat exchanger has an efficiency of 85%.
Both the supply and the outlet fan are placed before the rotating heat exchanger.

Window ventilation
The south-east and south-west window can be used to ventilate.
It is ventilated from June to August between 18.45 and 19.15.

Appendix 2. Average solar irradiation

Time[h]	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2	W/ m2
	jan	feb	mar	apr	mai	jun	jul	aug	Sep	okt	Nov	des
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	6,9	6,2	0	0	0	0	0
4	0	0	0	0	9,3	13,5	11,4	5,2	0	0	0	0
5	0	0	0	8,2	17,6	22,2	19,9	11,5	11,1	0	0	0
6	0	0	8,3	22,4	34,9	40,1	36,9	25,6	27,7	0	0	0
7	0	0	21,3	41,2	54,9	59,8	55,9	43,3	45,2	9,3	0	0
8	0	13,8	37,1	59,4	73,7	78,0	73,8	60,5	60,4	22,5	3,4	0
9	11,5	30,9	50,4	74,7	89,4	93,0	88,5	74,9	71,4	34,9	16,5	3,4
10	19,2	40,1	60,0	85,5	100,4	103,5	99,0	85,3	77,1	44,0	25,0	17,1
11	23,0	44,8	64,9	91,0	106,0	109,0	104,4	90,6	77,1	48,7	29,4	21,2
12	23,0	44,8	64,9	91,0	106,0	109,0	104,4	90,6	71,4	48,7	29,4	21,2
13	19,2	40,1	60,0	85,5	100,4	103,5	99,0	85,3	60,4	44,0	25,0	17,1
14	10,4	30,9	50,4	74,7	89,4	93,0	88,5	74,9	45,2	34,9	16,5	10,7
15	0	17,9	37,1	59,4	73,7	78,0	73,8	60,5	27,7	22,5	6,2	0
16	0	3,0	21,3	41,2	54,9	59,8	55,9	43,3	11,1	8,4	0	0
17	0	0	7,8	22,4	34,9	40,1	36,9	25,6	0	0	0	0
18	0	0	0	8,2	17,6	22,2	19,9	11,5	0	0	0	0
19	0	0	0	0	9,3	13,5	11,4	4,3	0	0	0	0
20	0	0	0	0	4,0	6,9	5,3	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0

Table : *Average solar irradiation in Oslo multiplied with a high PV panel efficiency of 0.2*